US009128439B2

(12) **United States Patent**
Miyadera et al.

(10) **Patent No.: US 9,128,439 B2**
(45) **Date of Patent: Sep. 8, 2015**

(54) **IMAGE FORMING APPARATUS AND CONVEYANCE CONTROL METHOD**

(71) Applicants: **Tatsuya Miyadera**, Kanagawa (JP); **Akinori Yamaguchi**, Osaka (JP); **Masatoshi Murakami**, Osaka (JP)

(72) Inventors: **Tatsuya Miyadera**, Kanagawa (JP); **Akinori Yamaguchi**, Osaka (JP); **Masatoshi Murakami**, Osaka (JP)

(73) Assignee: **RICOH COMPANY, LIMITED**, Tokyo (JP)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **14/093,740**

(22) Filed: **Dec. 2, 2013**

(65) **Prior Publication Data**

US 2014/0153943 A1 Jun. 5, 2014

(30) **Foreign Application Priority Data**

Dec. 3, 2012 (JP) 2012-264730
Dec. 3, 2012 (JP) 2012-264777
Dec. 3, 2012 (JP) 2012-264778

(51) **Int. Cl.**
G03G 15/00 (2006.01)
G03G 15/01 (2006.01)

(52) **U.S. Cl.**
CPC ***G03G 15/5062*** (2013.01); ***G03G 15/01*** (2013.01); ***G03G 15/5058*** (2013.01)

(58) **Field of Classification Search**
CPC G03G 15/5054; G03G 15/5058; G03G 15/5062
USPC 399/49, 388
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2006/0140650	A1*	6/2006	Yokote	399/27
2008/0069602	A1	3/2008	Miyadera	
2008/0130030	A1	6/2008	Okunishi et al.	
2008/0292369	A1*	11/2008	Takezawa	399/301
2009/0060599	A1*	3/2009	Sano et al.	399/301
2010/0232817	A1	9/2010	Miyadera et al.	
2010/0239331	A1	9/2010	Miyadera et al.	

(Continued)

FOREIGN PATENT DOCUMENTS

JP	10-148992	6/1998
JP	2003-307901	10/2003

(Continued)

OTHER PUBLICATIONS

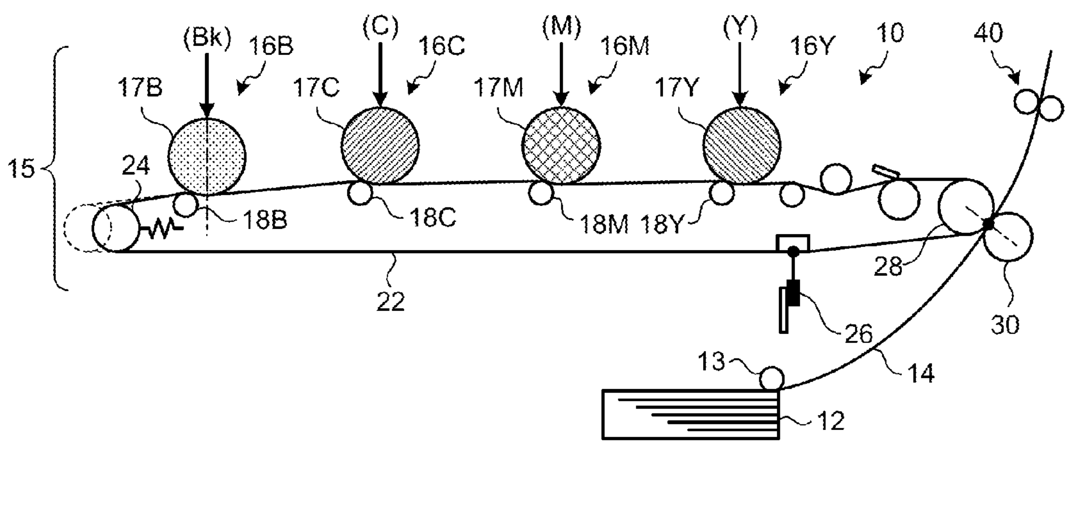
U.S. Appl. No. 13/919,261, filed Jun. 17, 2013.

Primary Examiner — G.M. Hyder
Assistant Examiner — Thomas Giampaolo, II
(74) *Attorney, Agent, or Firm* — Harness, Dickey & Pierce, P.L.C.

(57) **ABSTRACT**

An image forming apparatus including: a conveyance mechanism conveying a first pattern formed by a first image forming unit among image forming units, a second pattern formed by a second image forming unit among the image forming units; a detection unit detecting the first pattern and the second pattern; and a control unit controlling, when a first condition is satisfied, a timing of conveying a recording sheet having the image formed by the first image forming unit is transferred based on a first time required after the formation of the first pattern and before detecting the first pattern, and controlling, when a second condition is satisfied, a timing of conveying the recording sheet having the image formed by the second image forming unit is transferred based on a second time required after the formation of the second pattern and before detecting the second pattern.

20 Claims, 11 Drawing Sheets



(56) **References Cited**

U.S. PATENT DOCUMENTS

2010/0247124	A1*	9/2010	Aoki et al.	399/49
2011/0026082	A1	2/2011	Miyadera et al.	
2011/0228029	A1	9/2011	Miyadera et al.	
2011/0228364	A1	9/2011	Miyadera et al.	
2011/0229172	A1	9/2011	Miyadera et al.	
2012/0062681	A1	3/2012	Miyadera et al.	
2012/0207498	A1	8/2012	Miyadera et al.	
2012/0288291	A1	11/2012	Miyadera	
2013/0070040	A1	3/2013	Miyadera et al.	
2013/0259503	A1	10/2013	Miyadera et al.	

FOREIGN PATENT DOCUMENTS

JP	2004-287309	10/2004
JP	2007-241116	9/2007
JP	2008-033168	2/2008
JP	2008-076534	4/2008
JP	2008-139484	6/2008
JP	2011-048350	3/2011
JP	2011-197088	10/2011

* cited by examiner

FIG.1

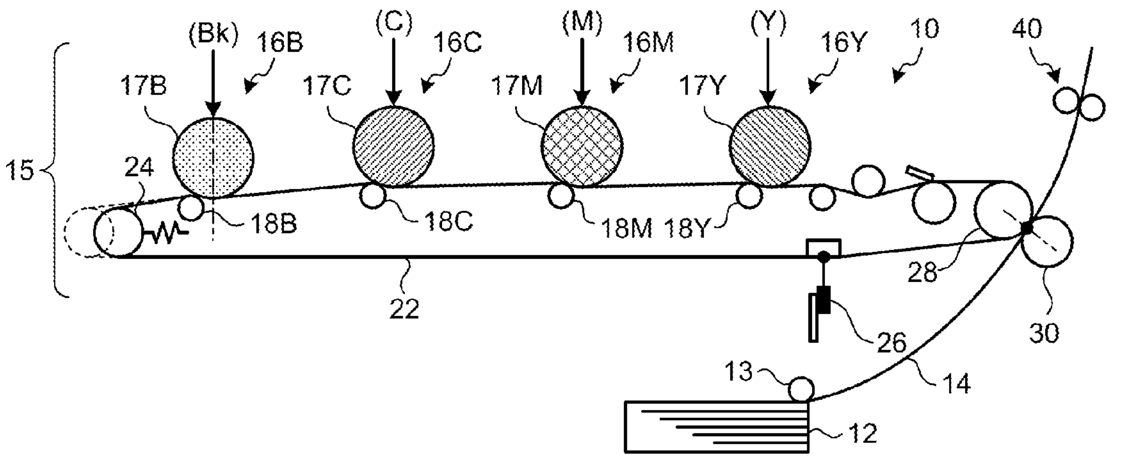

(Bk)
(C)
(M)
(Y)
16B
16C
16M
16Y
10
40
17B
17C
17M
17Y
15
24
18B
18C
18M
18Y
28
22
26
30
13
14
12

FIG.2

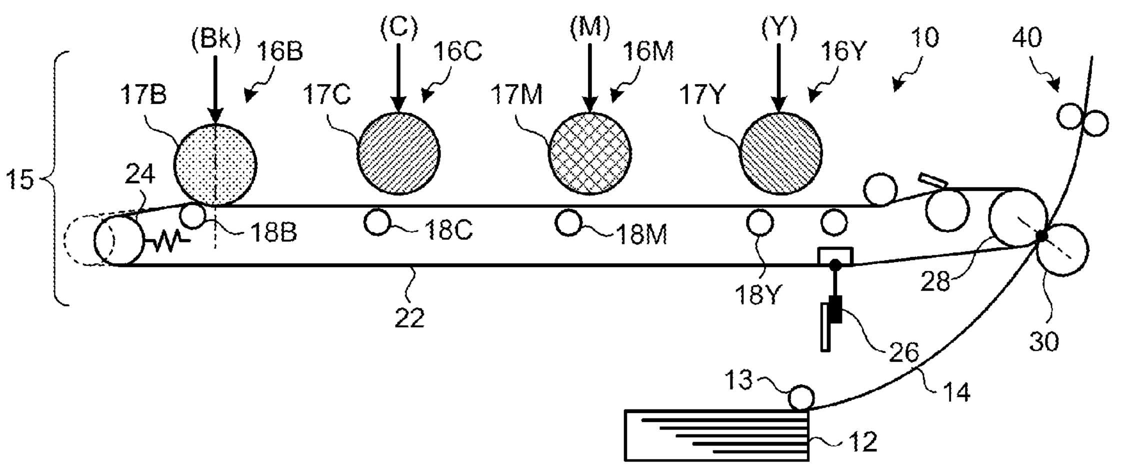

(Bk)
(C)
(M)
(Y)
16B
16C
16M
16Y
10
40
17B
17C
17M
17Y
15
24
18B
18C
18M
18Y
28
22
26
30
13
14
12

FIG.3

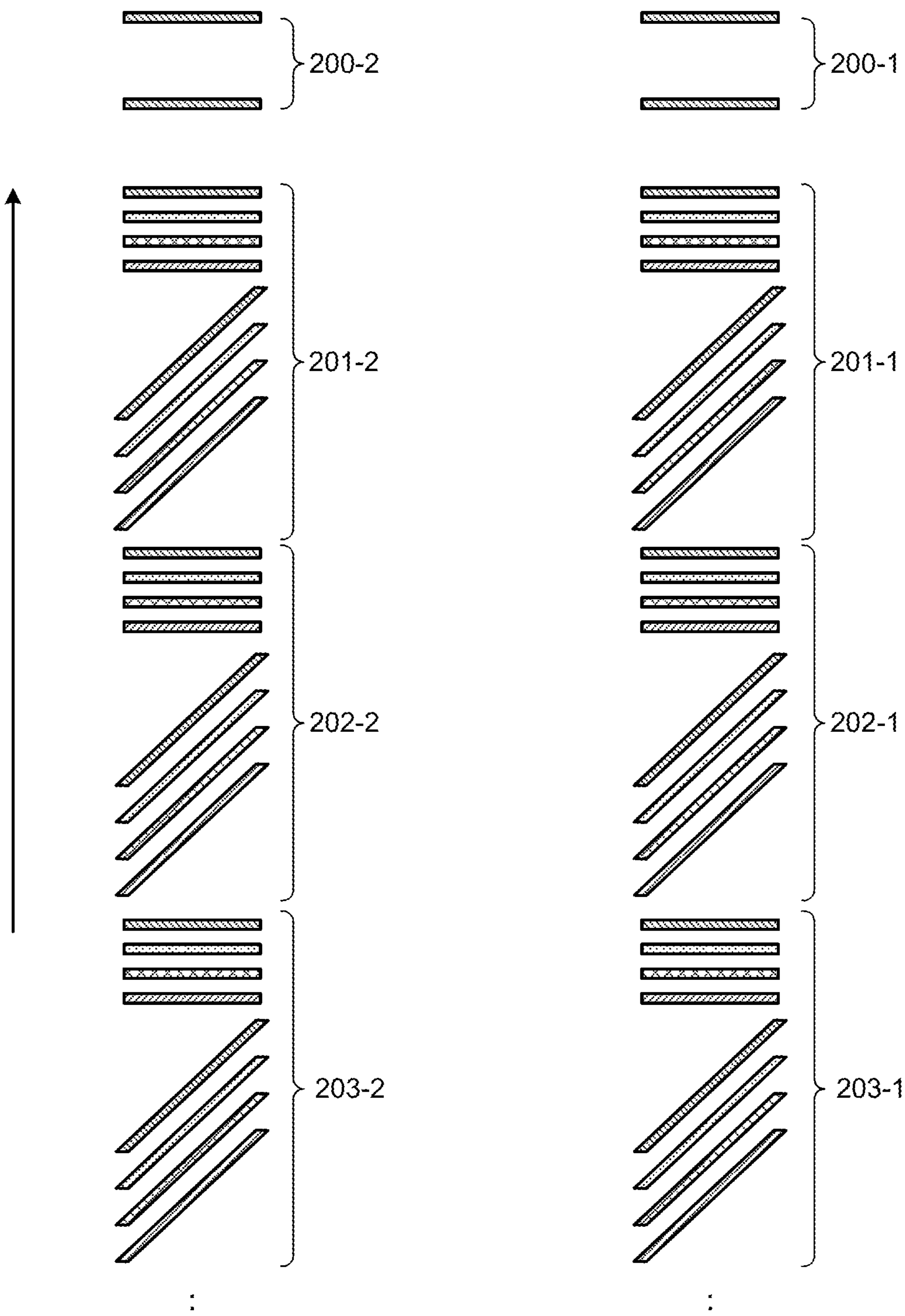


FIG.4


210-2
210-1

FIG.5

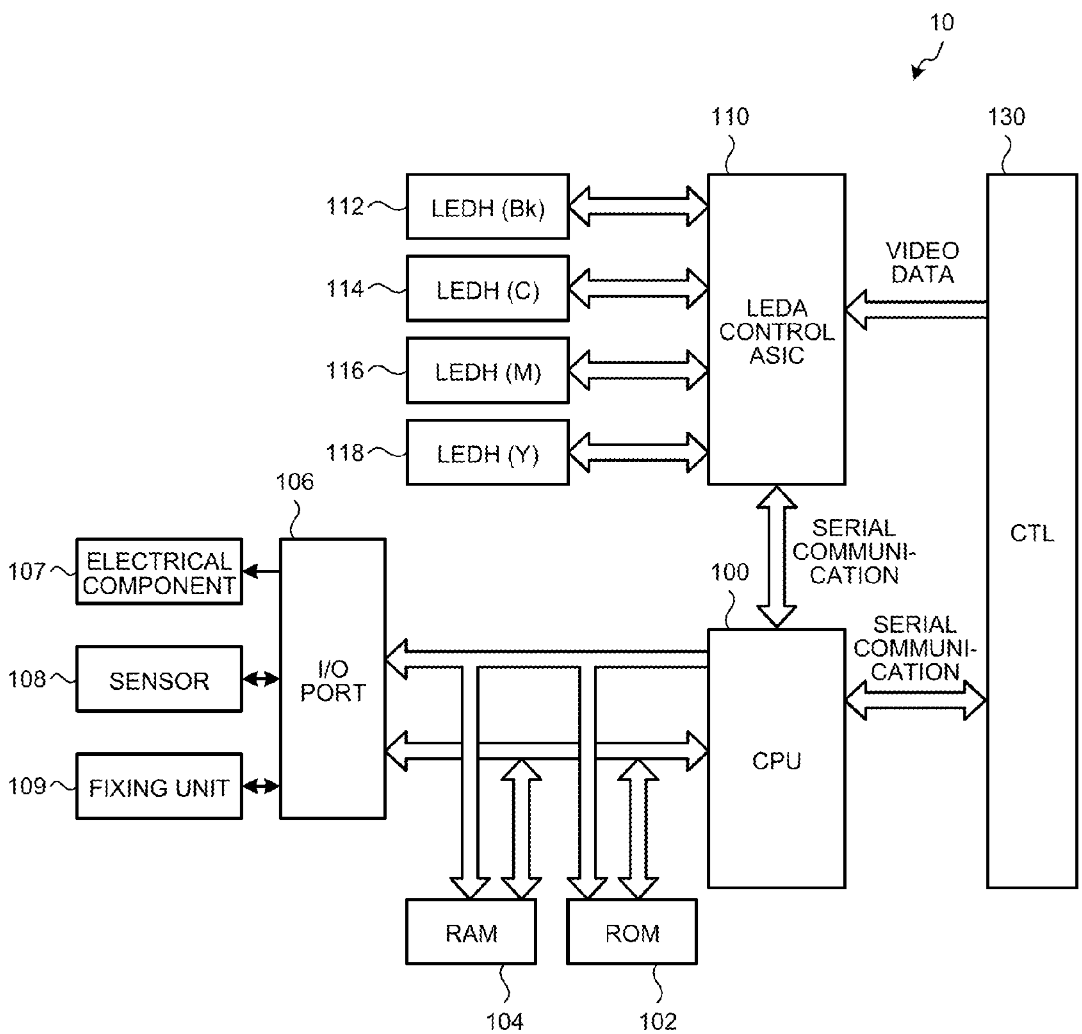

10
110
130
112
LEDH (Bk)
114
LEDH (C)
116
LEDH (M)
118
LEDH (Y)
LEDA CONTROL ASIC
VIDEO DATA
CTL
106
107
ELECTRICAL COMPONENT
108
SENSOR
109
FIXING UNIT
I/O PORT
SERIAL COMMUNI-CATION
100
SERIAL COMMUNI-CATION
CPU
RAM
ROM
104
102

FIG.6

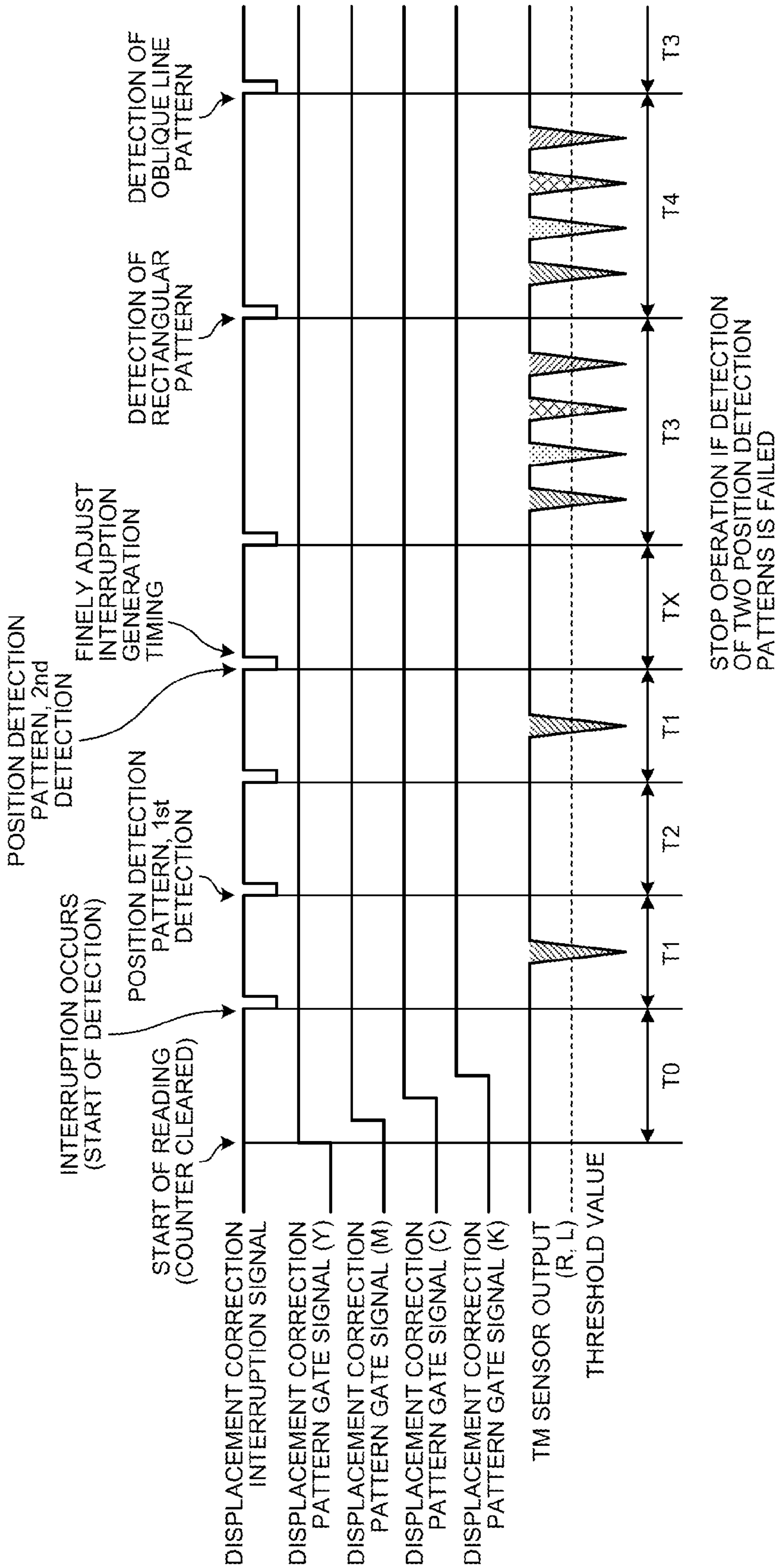

DISPLACEMENT CORRECTION INTERRUPTION SIGNAL
DISPLACEMENT CORRECTION PATTERN GATE SIGNAL (Y)
DISPLACEMENT CORRECTION PATTERN GATE SIGNAL (M)
DISPLACEMENT CORRECTION PATTERN GATE SIGNAL (C)
DISPLACEMENT CORRECTION PATTERN GATE SIGNAL (K)
TM SENSOR OUTPUT (R, L)
THRESHOLD VALUE
START OF READING (COUNTER CLEARED)
INTERRUPTION OCCURS (START OF DETECTION)
POSITION DETECTION PATTERN, 1st DETECTION
POSITION DETECTION PATTERN, 2nd DETECTION
FINELY ADJUST INTERRUPTION GENERATION TIMING
DETECTION OF RECTANGULAR PATTERN
DETECTION OF OBLIQUE LINE PATTERN
T0
T1
T2
T1
TX
T3
T4
T3
STOP OPERATION IF DETECTION OF TWO POSITION DETECTION PATTERNS IS FAILED

FIG.7

MODE	EVENT	CONTROL OPERATION	NOTE
COLOR PROHIBITION MODE	DETECTION OF END IN ANY OF C-, M-, AND Y-COLOR IMAGE FORMING UNITS	EXECUTE MONOCHROMATIC MODE ONLY	
Bk PRIORITY MODE	IF SETTING IS DONE BY USER EXCEPT THE EVENT IN THE FIRST ROW	EXECUTE NORMAL MODE AND MONOCHROMATIC MODE	EMPHASIZE REDUCTION OF COLOR TONER CONSUMPTION WHEN MONOCHROMATIC PRINTING IS PERFORMED MORE OFTEN
FC PRIORITY MODE	IF SETTING IS DONE BY USER EXCEPT THE EVENT IN THE FIRST ROW	EXECUTE NORMAL MODE ONLY	EMPHASIZE OPERATION AND QUALITY OF COLOR PRINTING

FIG.8

TIMING	JUDGING CRITERION	CONTROL OPERATION		
		FC PRIORITY MODE	Bk PRIORITY MODE	COLOR PROHIBITION MODE
BEFORE START OF JOB (COLOR)	NORMAL MODE = 1	NORMAL MODE EXECUTION	NORMAL MODE EXECUTION	
	MONOCHROMATIC MODE = 1	–	–	–
	OTHERS	–	–	
BEFORE START OF JOB (MONOCHROME)	NORMAL MODE = 1	NORMAL MODE EXECUTION	–	–
	MONOCHROMATIC MODE = 1	–	MONOCHROMATIC MODE EXECUTION	MONOCHROMATIC MODE EXECUTION
	OTHERS	–	–	–

FIG.9

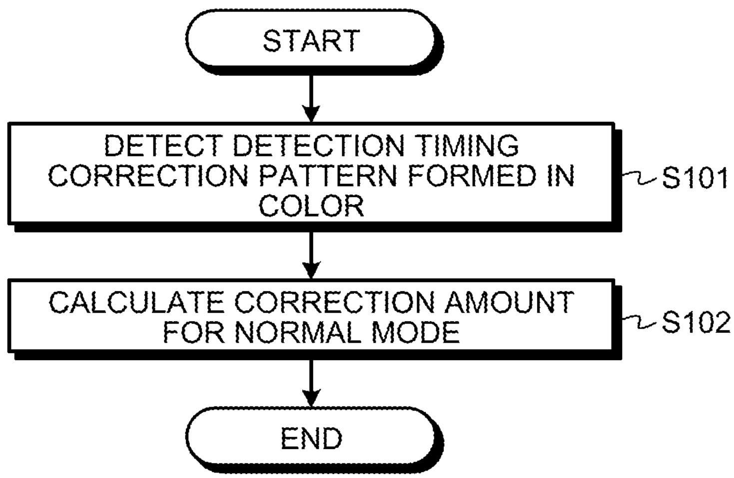

START
DETECT DETECTION TIMING CORRECTION PATTERN FORMED IN COLOR
S101
CALCULATE CORRECTION AMOUNT FOR NORMAL MODE
S102
END

FIG.10

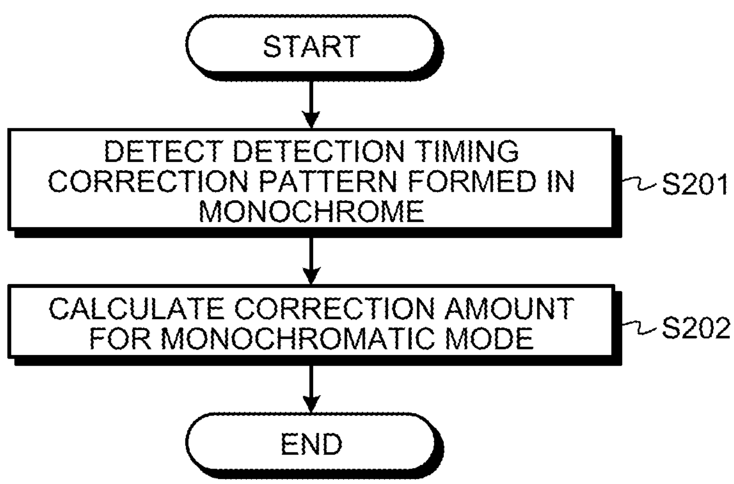

START
DETECT DETECTION TIMING CORRECTION PATTERN FORMED IN MONOCHROME
S201
CALCULATE CORRECTION AMOUNT FOR MONOCHROMATIC MODE
S202
END

FIG.11

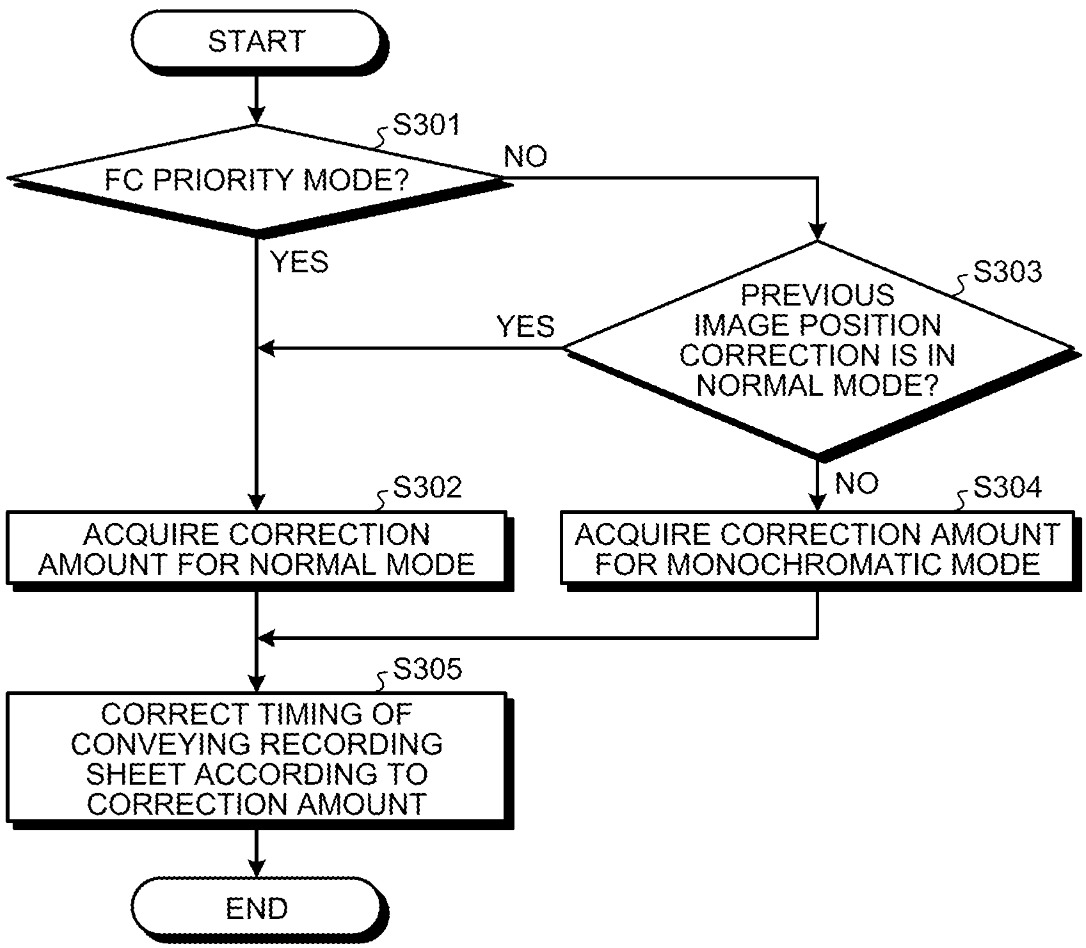

START
S301
FC PRIORITY MODE?
NO
YES
S303
PREVIOUS IMAGE POSITION CORRECTION IS IN NORMAL MODE?
YES
NO
S302
ACQUIRE CORRECTION AMOUNT FOR NORMAL MODE
S304
ACQUIRE CORRECTION AMOUNT FOR MONOCHROMATIC MODE
S305
CORRECT TIMING OF CONVEYING RECORDING SHEET ACCORDING TO CORRECTION AMOUNT
END

FIG.12

TIMING	JUDGING CRITERION	CONTROL OPERATION		
		FC PRIORITY MODE	Bk PRIORITY MODE	COLOR PROHIBITION MODE
POWER INPUT (EXCEPT RESTORATION FROM LIGHT DETECTION)	DETECT REST TIME HAS EXCEEDED THRESHOLD VALUE	SP:MUSIC EXECUTION REQUEST NORMAL MODE = 1	SP:MUSIC EXECUTION REQUEST NORMAL MODE = 1 SP:MUSIC EXECUTION REQUEST MONOCHROMATIC MODE = 1	SP:MUSIC EXECUTION REQUEST MONOCHROMATIC MODE = 1
RESTORATION FROM LIGHT DETECTION OR SLEEP MODE	DETECT REST TIME HAS EXCEEDED THRESHOLD VALUE	SP:MUSIC EXECUTION REQUEST NORMAL MODE = 1	SP:MUSIC EXECUTION REQUEST NORMAL MODE = 1 SP:MUSIC EXECUTION REQUEST MONOCHROMATIC MODE = 1	SP:MUSIC EXECUTION REQUEST MONOCHROMATIC MODE = 1
BEFORE START OF JOB (COLOR)	SP:MUSIC EXECUTION REQUEST NORMAL MODE = 1	NORMAL MODE EXECUTION	NORMAL MODE EXECUTION	–
	SP:MUSIC EXECUTION REQUEST MONOCHROMATIC MODE = 1	–	–	
	OTHERS	–	–	
BEFORE START OF JOB (MONOCHROME)	SP:MUSIC EXECUTION REQUEST NORMAL MODE = 1	NORMAL MODE EXECUTION	–	–
	SP:MUSIC EXECUTION REQUEST MONOCHROMATIC MODE = 1	–	MONOCHROMATIC MODE EXECUTION	MONOCHROMATIC MODE EXECUTION
	OTHERS	–	–	–
JOB END (COLOR)	SP:MUSIC EXECUTION REQUEST NORMAL MODE = 1	NOT EXECUTED	NOT EXECUTED	NOT EXECUTED
	SP:MUSIC EXECUTION REQUEST MONOCHROMATIC MODE = 1	NOT EXECUTED	NOT EXECUTED	
JOB END (MONOCHROME)	SP:MUSIC EXECUTION REQUEST NORMAL MODE = 1	NOT EXECUTED	NOT EXECUTED	NOT EXECUTED
	SP:MUSIC EXECUTION REQUEST MONOCHROMATIC MODE = 1	NOT EXECUTED	NOT EXECUTED	NOT EXECUTED

FIG.13

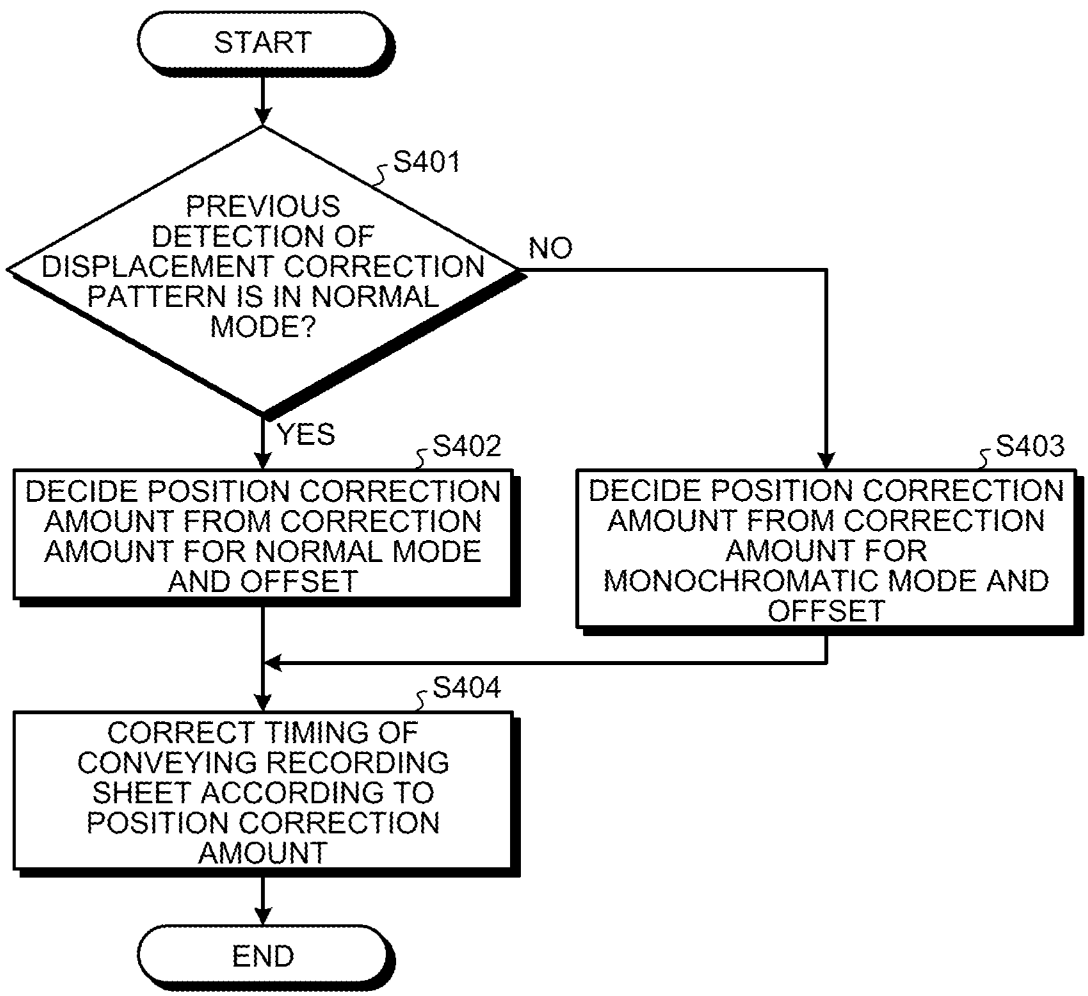

START
S401
PREVIOUS DETECTION OF DISPLACEMENT CORRECTION PATTERN IS IN NORMAL MODE?
NO
YES
S402
DECIDE POSITION CORRECTION AMOUNT FROM CORRECTION AMOUNT FOR NORMAL MODE AND OFFSET
S403
DECIDE POSITION CORRECTION AMOUNT FROM CORRECTION AMOUNT FOR MONOCHROMATIC MODE AND OFFSET
S404
CORRECT TIMING OF CONVEYING RECORDING SHEET ACCORDING TO POSITION CORRECTION AMOUNT
END

FIG.14

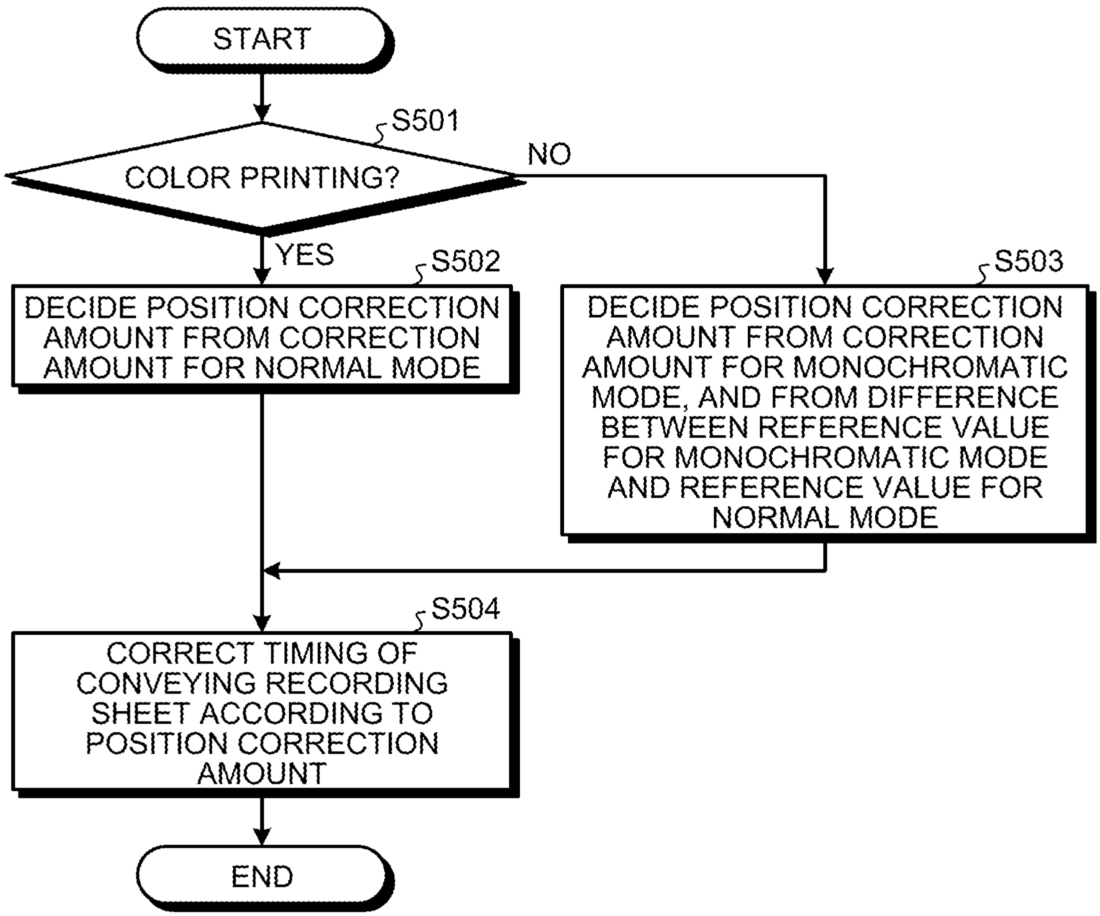

START
S501
COLOR PRINTING?
NO
YES
S502
DECIDE POSITION CORRECTION AMOUNT FROM CORRECTION AMOUNT FOR NORMAL MODE
S503
DECIDE POSITION CORRECTION AMOUNT FROM CORRECTION AMOUNT FOR MONOCHROMATIC MODE, AND FROM DIFFERENCE BETWEEN REFERENCE VALUE FOR MONOCHROMATIC MODE AND REFERENCE VALUE FOR NORMAL MODE
S504
CORRECT TIMING OF CONVEYING RECORDING SHEET ACCORDING TO POSITION CORRECTION AMOUNT
END

IMAGE FORMING APPARATUS AND CONVEYANCE CONTROL METHOD

CROSS-REFERENCE TO RELATED APPLICATIONS

The present application claims priority to and incorporates by reference the entire contents of Japanese Patent Application No. 2012-264730 filed in Japan on Dec. 3, 2012, Japanese Patent Application No. 2012-264777 filed in Japan on Dec. 3, 2012 and Japanese Patent Application No. 2012-264778 filed in Japan on Dec. 3, 2012.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to an image forming apparatus and a conveyance control method.

2. Description of the Related Art

In an electrophotography image forming apparatus, an intermediate transfer belt to which an image formed by an image forming unit is transferred is expanded or contracted due to thermal expansion or contraction caused by the change in temperature.

In view of this, in order to form an image at an appropriate position on a recording sheet, it is necessary to perform image position correction for correcting the displacement in image transfer position or conveyance timing correction for correcting the paper conveyance timing in consideration of the expansion or contraction of the intermediate transfer belt.

In the technique disclosed in Japanese Patent Application Laid-open No. 2008-76534, based on the timing at which a first set of the displacement correction pattern is read, the timing of detecting second and subsequent sets of displacement correction patterns is decided. Therefore, even though the intermediate transfer belt is expanded or contracted, it is possible to perform the image position correction by certainly reading the displacement correction patterns of the second and subsequent sets.

Further, if a difference from a reference value of the time of detecting the displacement correction pattern is calculated and the conveyance timing correction is performed based on the calculated difference, the conveyance control of the recording sheet in consideration of the expansion and contraction of the intermediate transfer belt becomes possible.

In the conventional art as described above, the displacement correction pattern formed in color is used; however, from the viewpoint of the accuracy of the paper conveyance timing and the consumption of a developer, the conveyance timing correction using the displacement correction pattern formed in color may not be preferable.

The present invention has been made in view of the above circumstances, and an object is to provide an image forming apparatus and a conveyance control method, that can increase the accuracy of the conveyance control of the recording sheet while the extra consumption of a developer is reduced.

SUMMARY OF THE INVENTION

It is an object of the present invention to at least partially solve the problems in the conventional technology.

According to the present invention, there is provided: an image forming apparatus comprising: a plurality of image forming units configured to form an image in different colors; a conveyance mechanism configured to convey a first pattern formed using at least a first image forming unit among the image forming units, that forms the image in a first color, and

convey a second pattern formed using a second image forming unit among the image forming units, that forms the image in a second color; a detection unit configured to detect the first pattern conveyed by the conveyance mechanism and the second pattern conveyed by the conveyance mechanism; and a control unit configured to control, when a first condition is satisfied, a timing of conveying a recording sheet to which the image formed using at least the first image forming unit is transferred on the basis of a first time required after the formation of the first pattern and before the detection of the first pattern by the detection unit, and the control unit configured to control, when a second condition is satisfied, a timing of conveying the recording sheet to which the image formed using the second image forming unit is transferred on the basis of a second time required after the formation of the second pattern and before the detection of the second pattern by the detection unit.

The present invention also provides an image forming apparatus comprising: a plurality of image forming units configured to form an image in different colors; a conveyance mechanism configured to convey a first pattern formed using at least a first image forming unit among the image forming units, that forms the image in a first color, and convey a second pattern formed using a second image forming unit among the image forming units, that forms the image in a second color; a detection unit configured to detect the first pattern conveyed by the conveyance mechanism and the second pattern conveyed by the conveyance mechanism; a storage unit configured to store a first temperature at the detection of the first pattern and a second temperature at the detection of the second pattern; and a control unit configured to control, when the first pattern has been previously detected, a timing of conveying a recording sheet to which the image formed using at least the first image forming unit is transferred on the basis of a first time required after the formation of the first pattern and before the detection of the first pattern by the detection unit, the first temperature, and a current temperature, and the control unit configured to control, when the second pattern has been previously detected, a timing of conveying the recording sheet to which the image formed using the second image forming unit is transferred on the basis of a second time required after the formation of the second pattern and before the detection of the second pattern by the detection unit, the second temperature, and the current temperature.

The present invention also provides an image forming apparatus comprising: a plurality of image forming units configured to form an image in different colors; a conveyance mechanism configured to convey a first pattern formed using at least a first image forming unit among the image forming units, that forms the image in a first color, and convey a second pattern formed using a second image forming unit among the image forming units, that forms the image in a second color; a detection unit configured to detect the first pattern conveyed by the conveyance mechanism and detecting the second pattern conveyed by the conveyance mechanism; a storage unit configured to store therein position adjustment information representing for which one of the first image and the second image position adjustment on a recording sheet has been performed, a first reference value as a reference value of a first time required after the image formation of the first pattern and before the detection of the first pattern by the detection unit, and a second reference value as a reference value of a second time required after the image formation of the second pattern and before the detection of the second pattern by the detection unit; and a control unit configured to control, when the position adjustment information represents that the position adjustment for the first image on the recording sheet has been performed, a timing of conveying the recording sheet to which the image formed by the first image forming unit is transferred on the basis of the first time and the first reference value and controlling a timing of conveying the recording sheet to which the image formed by the second image forming unit is transferred on the basis of the second time, the first reference value, and the second reference value, and the control unit configured to control, when the position adjustment information represents that the position adjustment for the second image on the recording sheet has been performed, a timing of conveying the recording sheet to which the image formed by the first image forming unit is transferred on the basis of the first time, the first reference value, and the second reference value and controlling a timing of conveying the recording sheet to which the image formed by the second image forming unit is transferred on the basis of the second time and the second reference value.

The above and other objects, features, advantages and technical and industrial significance of this invention will be better understood by reading the following detailed description of presently preferred embodiments of the invention, when considered in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic diagram illustrating an example of an entire structure of a printer according to a first embodiment;

FIG. **2** is a schematic diagram illustrating an example of an entire structure of a printer according to the first embodiment;

FIG. **3** is a diagram illustrating an example of a displacement correction pattern formed in color according to the first embodiment;

FIG. **4** is a diagram illustrating an example of a displacement correction pattern formed in monochrome according to the first embodiment;

FIG. **5** is a diagram illustrating an example of a hardware structure of the printer according to the first embodiment;

FIG. **6** is a diagram illustrating an example of a timing of detecting the displacement correction pattern formed in color according to the first embodiment;

FIG. **7** is an explanatory view of the FC priority mode, the Bk priority mode, and the color prohibition mode in the first embodiment;

FIG. **8** is an explanatory view of a timing of executing of the detection of the displacement correction pattern according to the first embodiment;

FIG. **9** is a flowchart of an example of a process of calculating the correction amount for the normal mode in the first embodiment;

FIG. **10** is a flowchart of an example of a process of calculating the correction amount for the monochromatic mode in the first embodiment;

FIG. **11** is a flowchart of an example of a process of correcting the conveyance timing in the first embodiment;

FIG. **12** is an explanatory view of a timing of executing of the detection of the displacement correction pattern according to a second embodiment;

FIG. **13** is a flowchart of an example of a process of correcting the conveyance timing in the second embodiment; and

FIG. **14** is a flowchart of an example of a process of correcting the conveyance timing in a third embodiment.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment

An embodiment of an image forming apparatus and a conveyance control method according to the present invention is hereinafter described in detail with reference to the attached drawings. Although an example of applying the image forming apparatus of the present invention to an electrophotography color printer is described in the embodiment below, the present invention is not limited thereto. The image forming apparatus of the present invention can be applied to any apparatus that forms a color image in electrophotography; for example, the present invention is applicable to an electrophotography copier or a multifunctional peripheral (MFP). Note that the multifunctional peripheral refers to an apparatus having at least two functions of a printing function, a copying function, a scanner function, and a facsimile function.

FIG. **1** and FIG. **2** are schematic diagrams illustrating an example of the entire structure of a printer **10** of this embodiment; FIG. **1** illustrates a state in which color printing (image formation) is performed while FIG. **2** illustrates a state in which monochromatic printing (image formation) is performed. As shown in FIG. **1** and FIG. **2**, the printer **10** includes a paper feeding tray **12**, a paper feeding roller **13**, a paper conveyance belt **14**, an image forming unit **15**, and a fixing unit **40**. Although FIG. **1** illustrates a so-called tandem printer in which image forming units of different colors are arranged along a conveyance belt as described later, the present invention is not limited thereto.

The paper feeding tray **12** has a plurality of recording sheets stacked therein.

The paper feeding roller **13** is in contact with the uppermost recording sheet of the recording sheets stacked in the paper feeding tray **12**, and feeds the uppermost recording sheet therefrom.

The recording sheet fed from the paper feeding roller **13** is sucked on the paper conveyance belt **14** by an electrostatic adsorption action, and the sucked recording sheet is conveyed to the image forming unit **15** (specifically, to the secondary transfer position).

The image forming unit **15** is to form an image on the recording sheet conveyed by the paper conveyance belt **14**, and includes image forming units **16**B, **16**C, **16**M, and **16**Y, an intermediate transfer belt **22**, a tension roller **24**, a toner marking sensor (hereinafter referred to as a TM sensor) **26**, a driving roller **28**, and a secondary transfer roller **30**.

The image forming units **16**B, **16**C, **16**M, and **16**Y are arranged along the intermediate transfer belt **22** in the order of the image forming units **16**Y, **16**M, **16**C, and **16**B from the upstream side of the conveyance direction of the intermediate transfer belt **22**.

The image forming unit **16**B includes a photosensitive drum **17**B, a charging device (not illustrated), a developing device (not illustrated), a transferring device **18**B, a photosensitive cleaner (not illustrated), and a neutralizing device (not illustrated), which are disposed around the photosensitive drum **17**B.

Note that each of the image forming units **16**C, **16**M, and **16**Y has components common to the image forming unit **16**B. In the example of FIG. **1** and FIG. **2**, the components of the image forming units **16**C, **16**M, and **16**Y are denoted by C, M, and Y, respectively instead of B of the components for the image forming unit **16**B.

In this embodiment, in the case of forming a color image, the photosensitive drums **17**B, **17**C, **17**M, and **17**Y are brought into contact with the intermediate transfer belt **22** as shown in FIG. **1**; in the case of forming a monochromatic image, the photosensitive drum **17**B is brought into contact with the intermediate transfer belt **22** and the photosensitive drums **17**C, **17**M, and **17**Y are lifted up from the intermediate transfer belt **22** as shown in FIG. **2**.

The image forming unit **16**B and a LEDA (Light Emitting Diode Array) head (not illustrated) perform the image formation process (charging step, exposing step, developing step, transferring step, cleaning step, and neutralizing step) in a state that the photosensitive drum **17**B is in contact with the intermediate transfer belt **22**; thus, a black toner image is formed on the intermediate transfer belt **22**.

Similarly, the image forming unit **16**C and a LEDA head perform the image formation process in a state that the photosensitive drum **17**C is in contact with the intermediate transfer belt **22**; thus, a cyan toner image is formed on the intermediate transfer belt **22**. The image forming unit **16**M and a LEDA head perform the image formation process in a state that the photosensitive drum **17**M is in contact with the intermediate transfer belt **22**; thus, a magenta toner image is formed on the intermediate transfer belt **22**. The image forming unit **16**Y and a LEDA head perform the image formation process in a state that the photosensitive drum **17**Y is in contact with the intermediate transfer belt **22**; thus, a yellow toner image is formed on the intermediate transfer belt **22**.

In other words, in this embodiment, in the case of forming the color image, the image forming units **16**B, **16**C, **16**M, and **16**Y perform the image forming process; on the other hand, in the case of forming the monochromatic image, the image forming unit **16**B performs the image forming process but the image forming units **16**C, **16**M, and **16**Y do not perform the image forming process.

The description is hereinafter made of the image forming process of the image forming unit **16**B mainly, and the description of the image forming process of the image forming units **16**C, **16**M, and **16**Y is omitted.

The photosensitive drum **17**B is rotated and driven by a driving motor, which is not illustrated.

First, in the charging step, the outer peripheral surface of the photosensitive drum **17**B driven and rotated is uniformly charged by the charging device in darkness.

Then, in the exposing step, the outer peripheral surface of the photosensitive drum **17**B driven and rotated is irradiated with irradiation light (Bk) corresponding to the black image from the LEDA head, thereby forming an electrostatic latent image based on the black image on the photosensitive drum **17**B.

Subsequently, in the developing step, the developing device develops the electrostatic latent image formed on the photosensitive drum **17**B with black toner, thereby forming a black toner image on the photosensitive drum **17**B.

Then, in the transferring step, the transferring device **18**B transfers the black toner image formed on the photosensitive drum **17**B to the intermediate transfer belt **22** at a primary transfer position where the transferring device **18**B is in contact with the photosensitive drum **17**B. Note that a slight amount of untransferred toner remains on the photosensitive drum **17**B after the transfer of the toner image.

Subsequently, in the cleaning step, the photosensitive cleaner removes the untransferred toner remaining on the photosensitive drum **17**B.

Finally, in the neutralizing step, the neutralizing device neutralizes the remaining potential on the photosensitive drum **17**B. Then, the image forming unit **16**B stands-by for the next image formation.

The intermediate transfer belt **22** (an example of the conveyance mechanism) is an endless belt wound around the tension roller **24** and the driving roller **28**, and the belt is moved endlessly in the order of the image forming units **16**Y, **16**M, **16**C, and **16**B when the driving roller **28** is driven and rotated by the driving motor, which is not illustrated.

As shown in FIG. **1**, in the case of forming the color image, first, the yellow toner image is transferred to the intermediate transfer belt **22** by the image forming unit **16**Y, and then, the magenta toner image, the cyan toner image, and the black toner image are transferred in the overlapped state by the image forming units **16**M, **16**C, and **16**B, respectively. Thus, the full-color image is formed on the intermediate transfer belt **22**.

As shown in FIG. **2**, in the case of forming the monochromatic image, the black toner image is transferred to the intermediate transfer belt **22** by the image forming unit **16**B. Thus, the monochromatic image is formed on the intermediate transfer belt **22**.

As soon as the image formed on the intermediate transfer belt **22** reaches a secondary transfer position where the secondary transfer roller **30** is in contact with the driving roller **28**, the recording sheet conveyed by the paper conveyance belt **14** is pressed against the image formed on the intermediate transfer belt **22** at the secondary transfer position. Thus, the image is transferred to the recording sheet from the intermediate transfer belt **22**.

The fixing unit **40** fixes the image transferred to the recording sheet by heating and pressing the recording sheet conveyed by the paper conveyance belt **14**. The recording sheet having the image fixed thereon is discharged out of the printer **10**.

The tension roller **24** absorbs the entire expansion of the intermediate transfer belt **22** caused by the temperature change by applying tension to the intermediate transfer belt **22**. In other words, in this embodiment, the intermediate transfer belt **22** is not expanded uniformly but the expansion of the intermediate transfer belt **22** due to the temperature change is collected to the tension roller **24**.

In this embodiment, the tension roller **24** is positioned in a route of the intermediate transfer belt **22** from the primary transfer position on the most downstream side (the primary transfer position where the photosensitive drum **17**B is in contact with the transferring device **18**B) to the TM sensor **26**.

Therefore, in this embodiment, if the influence of the temperature change is equal, the amount of expansion of the intermediate transfer belt **22** in the image conveyance distance of the intermediate transfer belt **22** in the case of forming the color image (distance from the first primary transfer position where the photosensitive drum **17**B is in contact with the transferring device **18**B to the secondary transfer position) becomes equal to the amount of expansion of the intermediate transfer belt **22** in the image conveyance distance of the intermediate transfer belt **22** in the case of forming the monochromatic image (distance from the first primary transfer position where the photosensitive drum **17**B is in contact with the transferring device **18**B to the secondary transfer position).

The TM sensor **26** (an example of detector) is, for example, a photosensor, and reads a displacement correction pattern formed on the intermediate transfer belt **22**. In this embodiment, in the case of forming the color image as shown in FIG. **1**, the displacement correction pattern (an example of a first pattern) is formed in four colors on the intermediate transfer belt **22** by the image forming units **16**B, **16**C, **16**M, and **16**Y; in the case of forming the monochromatic image as shown in FIG. **2**, the displacement correction pattern (an example of a second pattern) is formed in monochrome on the intermediate transfer belt **22** by the image forming unit **16**B.

FIG. **3** illustrates an example of the displacement correction pattern formed in color of this embodiment. As shown in FIG. **3**, the displacement correction pattern formed in color includes detection timing correction patterns **200-1** and **200-2** at the head, which are followed by correction pattern rows **201-1** to **203-1** and **201-2** to **203-2**, respectively.

The detection timing correction patterns **200-1** and **200-2** are each formed of two Y-color linear patterns. The correction pattern rows **201-1** to **203-1** and **201-2** to **203-2** are each formed of eight pattern rows in total: four linear patterns and four oblique patterns. The four linear patterns and the four oblique patterns are each formed of four colors of Y, B, M, and C.

In the example of FIG. **3**, the number of correction pattern rows disposed in a sub-scanning direction (the number of correction pattern rows disposed after the detection timing correction pattern) is three; however, the present invention is not limited thereto and may be any number. In the example of FIG. **3**, similarly, the two pattern rows each including the detection timing correction pattern and the correction pattern rows are provided in parallel; however, the present invention is not limited thereto and the number of rows may be determined in accordance with the number of TM sensors **26**.

By detecting the detection timing correction patterns **200-1** and **200-2** with the TM sensor **26**, the time after the image forming unit **16**Y forms (specifically, exposes) the detection timing correction patterns **200-1** and **200-2** and before the formed patterns reaches the detection position of the TM sensor **26** is detected.

Then, the difference between the detected time and a reference value (logical value) is calculated, and based on the calculated difference, the timing of reading out the correction pattern rows **201-1** to **203-1** and **201-2** to **203-2** with the TM sensor **26** is corrected, whereby the TM sensor **26** can surely detect the correction pattern rows **201-1** to **203-1** and **201-2** to **203-2**. Since the detection results reflect the displacement amount due to the tolerance of the incidence angle of the LEDA light on the photosensitive drum or the displacement amount due to the change in conveyance speed of the intermediate transfer belt, the image position correction can be performed. By using the calculated difference, similarly, the timing of conveying the recording sheet to the secondary transfer position by the paper conveyance belt **14** can be corrected.

In the example of FIG. **3**, the detection timing correction patterns **200-1** and **200-2** are formed in Y color because, in the case of the color image formation, the image forming unit **16**Y is in the most upstream side of the image forming process and the amount of delay is 0. As a result, the influence of the measurement error from hardware after the image formation of the detection timing correction patterns **200-1** and **200-2** by the image forming unit **16**Y to the detection of the patterns by the TM sensor **26** can be reduced, thereby increasing the accuracy of the image position correction or the conveyance timing correction.

FIG. **4** is a diagram illustrating an example of the displacement correction pattern formed in monochrome of this embodiment. As shown in FIG. **4**, the displacement correction pattern formed in monochrome includes detection timing correction patterns **210-1** and **210-2** at the head.

Each of the detection timing correction patterns **210-1** and **210-2** includes two linear patterns of the B color. In the example of FIG. **4**, the two pattern rows including the detection timing correction patterns are provided in parallel; however, the present invention is not limited thereto and the number of the pattern rows may be determined in accordance with the number of TM sensors **26**.

The TM sensor **26** detects the detection timing correction patterns **210-1** and **210-2**. Since the detection results reflect the displacement due to the tolerance of the incidence angle of the LEDA light on the photosensitive drum or the displacement due to the change in conveyance speed of the intermediate transfer belt, the image position correction can be performed.

By detecting the detection timing correction patterns **210-1** and **210-2** with the TM sensor **26**, the time after the image forming unit **16**Y forms (specifically, exposes) the detection timing correction patterns **210-1** and **210-2** and before the formed patterns reaches the detection position of the TM sensor **26** is detected. Then, the difference between the detected time and a reference value (logical value) is calculated, and based on the calculated difference, the timing of conveying the recording sheet to the secondary transfer position by the paper conveyance belt **14** can be corrected.

In the example of FIG. **4**, the detection timing correction patterns **210-1** and **210-2** are formed in the B color because, in the case of the monochromatic image formation, the image forming unit **16**B is in the most upstream side of the image forming process and the amount of delay is 0. As a result, the influence of the measurement error from hardware after the image formation of the detection timing correction patterns **210-1** and **210-2** by the image forming unit **16**B to the detection of the patterns by the TM sensor **26** can be reduced, thereby the accuracy of the image position correction or the conveyance timing correction is increased.

FIG. **5** is a diagram illustrating an example of a hardware structure of the printer **10** of this embodiment. As shown in FIG. **5**, the printer **10** includes: a CPU (Central Processing Unit) **100**; ROM (Read Only Memory) **102**; RAM (Random Access Memory) **104**; an I/O port **106**; an electrical component **107**; a sensor **108**; a fixing unit **109**; a LEDA control ASIC (Application Specific integrated Circuit) **110**; a LEDH (Bk) **112**; a LEDH(C) **114**; a LEDH(M) **116**; a LEDH(Y) **118**; and a CTL **130**.

The CTL **130** is a controller for controlling the printer **10**, and upon the reception of a print job from a host computer or the like, the CTL **130** transmits video data such as the image data included in the print job to the LEDA control ASIC **110**, performs serial communication with the CPU **100**, and orders the print control.

Upon the reception of the video data from the CTL **130**, the LEDA control ASIC **110** converts the received video data into signals for causing the LEDH(Bk) **112**, the LEDH(C) **114**, the LEDH(M) **116**, and the LEDH(Y) **118** to emit light. By making the LEDH(Bk) **112**, the LEDH(C) **114**, the LEDH (M) **116**, and the LEDH(Y) **118** emit light (illuminate) on the basis of the converted signals, the image data are written.

In conjunction with the writing of the image data by the LEDH(Bk) **112**, the LEDH(C) **114**, the LEDH(M) **116**, and the LEDH(Y) **118**, the image forming units **16**B, **16**C, **16**M, and **16**Y execute the image forming process by electrophotography and transfer the formed toner image to the sheet.

If the video data are the video data for the color image, the LEDA control ASIC **110** causes the LEDH(Bk) **112**, the LEDH(C) **114**, the LEDH(M) **116**, and the LEDH(Y) **118** to emit light (illuminate); however, if the video data are the video data for the monochromatic image, the LEDA control ASIC **110** causes only the LEDH(Bk) **112** to emit light (illuminate).

The CPU **100** uses the RAM **104** as a working area where the CPU **100** executes the program stored in the ROM **102** as flash ROM, thereby performing various controls over the printer **10**. For example, upon the reception of the order of the print control from the CTL **130**, the CPU **100** performs the serial communication with the LEDA control ASIC **110** to control the light emission timing of the LEDH(Bk) **112**, the LEDH(C) **114**, the LEDH(M) **116**, and the LEDH(Y) **118** or to control the electrical component **107**, the sensor **108** such as the TM sensor **26** or a temperature and humidity sensor (not illustrated), and the fixing unit **109** such as the fixing unit **40** via the I/O port **106**.

The CPU **100** performs the image position correction or the conveyance timing correction. The description is hereinafter made of the image position correction or the conveyance timing correction by the CPU **100**.

First, the image position correction is described with reference to FIG. **6**.

FIG. **6** is a diagram depicting an example of the timing of detecting the displacement correction pattern formed in color according to this embodiment.

First, at the same time as the start of the image formation of the detection timing correction pattern **200-1** (gate signal assert), the pattern detection counter is reset.

Subsequently, the CPU **100** sets the interruption signal generation timing T**0** (several milliseconds before the detection of the detection timing correction pattern **200-1**), and when the time has reached T**0**, the interruption signal is generated and the pattern detection counter is reset at the same time again. Then, the CPU **100** sets the next interruption signal generation timing T**1**.

Next, since the TM sensor **26** detects the detection timing correction pattern **200-1** before T**1**, the output signal intersects with the threshold value on this timing and the counter value in the pattern detection counter is saved in a timing storage register.

Subsequently, when the time has reached T**1**, the interruption signal is generated; therefore, the CPU **100** reads out the counter value from the timing storage register. From this counter value, the time after the start of the image formation of the detection timing correction pattern **200-1** and before the detection of the first linear pattern of the detection timing correction pattern **200-1** by the TM sensor **26** can be specified.

Then, the CPU **100** sets the interruption signal generation timing T**2**, and repeats the process from the setting of T**0** to the acquisition of the counter value once again; thus, the counter value is acquired. From this counter value, the time after the start of the image formation of the detection timing correction pattern **200-1** and before the detection of the second linear pattern of the detection timing correction pattern **200-1** by the TM sensor **26** can be specified.

The CPU **100** compares a reference value (an example of a first reference value) for the displacement correction pattern formed in color with the time after the start of the image formation of the detection timing correction pattern **200-1** and before the detection of at least one of the first linear pattern and the second linear pattern of the detection timing correction pattern **200-1** by the TM sensor **26**, and calculates the correction amount (difference). The reference value for the displacement correction pattern formed in color is, for example, measured in advance and stored in the ROM **102**.

Thus, the CPU **100** can know the displacement of the timing of detecting the displacement correction pattern formed in color; therefore, the next interruption signal generation timing TX is calculated and set based on this correction amount. As a result, the CPU **100** can generate the interruption signal at the timing suitable for acquiring the detection results of the correction pattern rows **201-1** to **203-1**.

Next, when the time has reached the timing TX, the interruption signal is generated; therefore, the CPU **100** sets the interruption signal generation timing T**3** for the linear pattern of the correction pattern row **201-1** and the interruption signal generation timing T**4** for the oblique pattern of the correction pattern row **201-1** in this order. Thus, the CPU **100** can acquire the detection results of the linear pattern or the oblique pattern of the correction pattern row **201-1** at the optimal timing. This similarly applies to the correction pattern rows **202-1** and **203-1**.

Then, in accordance with the detection results of the correction pattern rows **201-1** to **203-1**, the CPU **100** causes the LEDA control ASIC **110** to correct the light emission timings of the LEDH(Bk) **112**, the LEDH(C) **114**, the LEDH(M) **116**, and the LEDH(Y) **118**, thereby the CPU **100** performs the image position correction.

The above description made of the detection timing correction pattern **200-1** and the correction pattern rows **201-1** to **203-1** similarly applies to the detection timing correction pattern **200-2** and the correction pattern rows **201-2** to **203-2**.

In the case of the displacement correction pattern formed in monochrome, the CPU **100** performs the detection of the detection timing correction patterns **210-1** and **210-2** in a manner similar to the detection of the detection timing correction patterns **200-1** and **200-2**, and using the detection results of the detection timing correction patterns **210-1** and **210-2**, the CPU **100** performs the image position correction.

Next, the conveyance timing correction is described. Note that in the description below, the correction amount is calculated on the premise that the following conditions (1) to (6) are satisfied:

(1) the number of rotations of the photosensitive drum does not change even though the environment changes or the time has passed;

(2) the amount of change in distance from the primary transfer position to the secondary transfer position due to the expansion of the intermediate transfer belt is the same in the case of forming either the color image or the monochromatic image;

(3) the number of rotations of the photosensitive drum does not change in the case of forming either the color image or the monochromatic image;

(4) the linear velocity of the intermediate transfer belt does not change in the case of forming either the color image or the monochromatic image;

(5) the opening or closing of the cover does not change the position of the LEDA exposure; and

(6) the exchange of PCDU does not change the primary transfer position.

In the description below, "the detection of the displacement correction pattern formed in color" may be referred to as "the detection of the displacement correction pattern in the normal mode", "the reference value for the displacement correction pattern formed in color" may be referred to as "the reference value for the normal mode", "the detection timing correction pattern **200-1**" may be referred to as "the detection timing correction pattern (Y)R", and "the detection timing correction pattern **200-2**" may be referred to as "the detection timing correction pattern (Y)L".

Similarly, in the description below, "the detection of the displacement correction pattern formed in monochrome" may be referred to as "the detection of the displacement correction pattern in the monochromatic mode", "the reference value for the displacement correction pattern formed in monochrome" may be referred to as "the reference value for the monochromatic mode", "the detection timing correction pattern **210-1**" may be referred to as "the detection timing correction pattern (B)R", and "the detection timing correction pattern **210-2**" may be referred to as "the detection timing correction pattern (B)L".

In the case of the detection of the displacement correction pattern in the normal mode, the CPU **100** calculates the correction amount for the normal mode using Formula (1).

$$\text{Correction amount for the normal mode}=\{(\text{measurement value of detection timing correction pattern }(Y)R+\text{measurement value of detection timing correction pattern }(Y)L)/2-\text{reference value for the normal mode}\}\times\text{sampling length }d1\,[\mu m] \quad (1)$$

In the case of the detection of the displacement correction pattern in the monochromatic mode, the CPU **100** calculates the correction amount for the normal mode using Formula (2).

$$\text{Correction amount for the normal mode}=\{(\text{measurement value of detection timing correction pattern }(B)R+\text{measurement value of detection timing correction pattern }(B)L)/2-\text{reference value for the monochromatic mode}\}\times\text{sampling length }d1\,[\mu m] \quad (2)$$

In a manner similar to the reference value for the normal mode, the reference value for the monochromatic mode is also measured and stored in the ROM **102** in advance. The correction amount for the normal mode and the correction amount for the monochromatic mode consist of significant five digits (−32768 to 32767); however, the present invention is not limited thereto.

When the first condition is satisfied, the CPU **100** controls the conveyance timing for the recording sheet to which the color image is transferred, by using the correction amount for the normal mode; when the second condition is satisfied, the CPU **100** controls the conveyance timing for the recording sheet to which the monochromatic image is transferred, by using the correction amount for the monochromatic mode.

Specifically, if the first condition is satisfied, the CPU **100** determines the position correction amount ΔP [μm] from the correction amount for the normal mode, and based on the position correction amount ΔP [μm], the CPU **100** corrects and controls the timing of feeding paper from the paper feeding roller **13** or the timing of conveying the recording sheet with the paper conveyance belt **14**. Similarly, if the second condition is satisfied, the CPU **100** determines the position correction amount ΔP [μm] from the correction amount for the monochromatic mode, and based on the position correction amount ΔP [μm], the CPU **100** corrects and controls the timing of feeding paper from the paper feeding roller **13** or the timing of conveying the recording sheet with the paper conveyance belt **14**.

If the mode of the printer **10** is the FC priority mode for putting priority on the color image formation, the first condition is satisfied. Moreover, if the mode of the printer **10** is the Bk priority mode for putting priority on the monochromatic image formation or is the color prohibition mode for prohibiting the color image formation, the first condition is satisfied as long as the previous detection of the displacement correction pattern is the detection of the displacement correction pattern in the normal mode. On the other hand, if the mode of the printer **10** is the Bk priority mode for putting priority on the monochromatic image formation or is the color prohibition mode for prohibiting the color image formation, the second condition is satisfied as long as the previous detection of the displacement correction pattern is the detection of the displacement correction pattern in the monochromatic mode.

Whether the previous detection of the displacement correction pattern is the detection of the displacement correction pattern in the normal mode or the detection of the displacement correction pattern in the monochromatic mode is stored as the information in the ROM **102** every time when the CPU **100** detects the displacement correction pattern, and this information may be referred to.

FIG. **7** is an explanatory view of the FC priority mode, the Bk priority mode, and the color prohibition mode of this embodiment. As shown in FIG. **7**, the FC priority mode and the Bk priority mode are the modes set by the CPU **100** when the setting is ordered by a user through an operation panel or the like, which is not illustrated. The color prohibition mode is the mode set by the CPU **100** upon the detection of the toner end of any of the cyan toner, the yellow toner, and the magenta toner.

The FC priority mode is the mode in which the operation and quality of the color printing are considered important, and is executed only in the normal mode (image formation in color). The Bk priority mode is the mode in which the reduction of the consumption of the color toner (cyan toner, yellow toner, and magenta toner) is considered important when the monochromatic printing is performed more often, and is executed not just in the monochromatic mode (image formation in monochrome) but also in the normal mode (image formation in color). The color prohibition mode is the mode in which the color printing is prohibited, and is executed only in the monochromatic mode (image formation in monochrome).

Next, the timing of executing the detection of the displacement correction pattern is described. FIG. **8** is an explanatory view of the timing of executing the detection of the displacement correction pattern according to this embodiment. In this embodiment, basically, the detection of the displacement correction pattern is executed before the start of the job; however, the timing of the execution is not limited thereto.

It is assumed that the detection of the displacement correction pattern in the normal mode is requested before the start of the job for the color. In this case, if the mode is the FC priority mode or the Bk priority mode, the CPU **100** executes the detection of the displacement correction pattern in the normal mode before the start of the job for the color.

It is assumed that the detection of the displacement correction pattern in the normal mode is requested before the start of the job for the monochrome. In this case, if the mode is the FC priority mode, the CPU **100** executes the detection of the displacement correction pattern in the normal mode before the start of the job for the monochrome.

It is assumed that the detection of the displacement correction pattern in the monochromatic mode is requested before the start of the job for the monochrome. In this case, if the mode is the Bk priority mode or the color prohibition mode, the CPU **100** executes the detection of the displacement correction pattern in the monochromatic mode before the start of the job for the monochrome.

FIG. **9** is a flowchart of an example of a process of calculating the correction amount for the normal mode in this embodiment.

First, upon the execution of the detection of the displacement correction pattern in the normal mode, the displacement correction pattern are formed in four colors on the intermediate transfer belt **22** by the image forming units **16**B, **16**C, **16**M, and **16**Y, and the detection timing correction patterns **200-1** and **200-2** of the displacement correction pattern are detected by the TM sensor **26** (Step S**101**).

Subsequently, the CPU **100** acquires the counter value for specifying the time after the start of the image formation of the detection timing correction patterns **200-1** and **200-2** and before the detection thereof by the TM sensor **26**, and a reference value for the normal mode. Using Formula (1), the CPU **100** calculates the correction amount for the normal mode and stores the calculated amount in the ROM **102** (Step S**102**).

FIG. **10** is a flowchart of an example of a process of calculating the correction amount for the monochromatic mode according to this embodiment.

First, upon the execution of the detection of the displacement correction pattern in the monochromatic mode, the displacement correction pattern formed in monochrome is formed on the intermediate transfer belt **22** by the image forming unit **16**B, and the detection timing correction patterns **210-1** and **210-2** of the displacement correction pattern are detected by the TM sensor **26** (Step S**201**).

Subsequently, the CPU **100** acquires the counter value for specifying the time after the start of the image formation of the detection timing correction patterns **210-1** and **210-2** and before the detection thereof by the TM sensor **26**, and a reference value for the monochromatic mode. Using Formula (2), the CPU **100** calculates the correction amount for the monochromatic mode and stores the calculated amount in the ROM **102** (Step S**202**).

FIG. **11** is a flowchart of an example of a process of correcting the conveyance timing according to this embodiment.

First, the CPU **100** checks whether the mode of the printer **10** is the FC priority mode or not before the start of the printing (Step S**301**), and when the mode is the FC priority mode (Yes in Step S**301**), the CPU **100** acquires the correction amount for the normal mode from the ROM **102** (Step S**302**).

When the mode is not the FC priority mode (No in Step S**301**), the mode is the Bk priority mode or the color prohibition mode; therefore, the CPU **100** checks whether or not the previous detection of the displacement correction pattern (image position correction) has been performed in the normal mode (Step S**303**).

When the mode is the normal mode (Yes in Step **3303**), the CPU **100** acquires the correction amount for the normal mode from the ROM **102** (Step S**302**); when the mode is not the normal mode but the monochromatic mode (No in Step S**303**), the CPU **100** acquires the correction amount for the monochromatic mode from the ROM **102** (Step S**304**).

Subsequently, the CPU **100** determines the position correction amount calculated from the acquired correction amount, and using the position correction amount, the CPU **100** corrects and controls the timing of feeding paper from the paper feeding roller **13** or the timing of conveying the recording sheet by the paper conveyance belt **14** (Step S**305**).

As described above, in this embodiment, the detection of the displacement correction pattern is performed using not just the color but also the monochrome; by using the detection results (detection time) obtained from the monochrome, the conveyance control for the recording sheet is performed.

Therefore, according to this embodiment, in the case of performing only the monochromatic printing, the conveyance control for the recording sheet is performed using the detection results obtained from the monochrome instead of the detection results obtained from the color. Therefore, the accuracy of the conveyance control for the recording sheet can be increased while the extra consumption of the toner is reduced.

In contrast to this, in the case of performing the detection of the displacement correction pattern using the color, even though only the monochromatic printing is performed, the conveyance control for the recording sheet is performed using the detection results obtained from the color. This results in the extra consumption of color toner.

Further, in the case where the image forming unit in the most upstream side is different for the color image formation and the monochromatic image formation like in the printer of this embodiment, the expansion amount of the intermediate transfer belt over the distance for conveying the color image and the expansion amount of the intermediate transfer belt over the distance for conveying the monochromatic image are different even under the same influence of the temperature change unless the tension roller is disposed. Therefore, in the case of detecting the displacement correction pattern using color only, in order to perform the conveyance control for the recording sheet at the monochromatic printing, the detection results obtained from the color needs to be subjected to predetermined conversion. Therefore, the conveyance control for the recording sheet at the monochromatic printing is less accurate than that at the color printing.

According to this embodiment, in any case of the color and monochromatic printings, the image forming unit in the most upstream side in the image forming process forms the detection timing correction pattern; therefore, the influence of the measurement error from the hardware can be reduced and the accuracy of the image position correction and the conveyance timing correction can be increased further.

According to this embodiment, both the image position correction and the conveyance timing correction are performed using the detection result of the displacement correction pattern; therefore, the extra toner consumption can be reduced.

In this embodiment, if the use of the FC priority mode as a default is assumed, the detection of the displacement correction pattern in the normal mode is mainly performed and in some cases, the printing in the monochromatic mode is performed. Therefore, in the case where the image forming unit in the most upstream side is different in the color image formation and the monochromatic image formation as described in this embodiment, it is preferable to dispose the tension roller so that the expansion amount of the intermediate transfer belt over the distance for conveying the color image and the expansion amount of the intermediate transfer belt over the distance for conveying the monochromatic image are the same value.

Second Embodiment

As described above, in the technique disclosed in Japanese Patent Application Laid-open No. 2008-76534, for example, based on the timing of reading the first set of the displacement correction pattern, the timing of detecting the second and subsequent sets of the displacement correction pattern is decided. Thus, even though the intermediate transfer belt is expanded or contracted, the second set and subsequent sets of the displacement correction patterns can be read surely to perform the image position correction.

Moreover, the difference from the reference value of the detection time of the displacement correction pattern is calculated, and if the conveyance timing correction is performed based on the calculated difference, the conveyance control for the recording sheet considering the expansion or the contraction of the intermediate transfer belt becomes possible.

In this case, the image position correction and the conveyance timing correction are performed commonly using the detection results of the displacement correction pattern; therefore, the timing of executing the both corrections is the same.

Therefore, in the case of an image forming apparatus where the displacement is unlikely to occur, the image position correction is performed less frequently, and accordingly, the conveyance timing correction is performed less frequently. As a result, the execution frequency of the conveyance timing correction is insufficient, resulting in that the expansion and the contraction of the intermediate transfer belt cannot be absorbed in the conveyance control for the recording sheet and the recording sheet may be unable to be conveyed at the appropriate timing.

Here, if the conveyance timing correction is performed more frequently by detecting the displacement correction pattern for the conveyance timing correction independently, it is possible to absorb the expansion and the contraction of the intermediate transfer belt in the conveyance control for the recording sheet; however, in this case, the developer is consumed more.

In view of this, the second embodiment describes an example of increasing the accuracy of the conveyance control for the recording sheet while the consumption of the developer is suppressed. The description below is mainly made of the difference from the first embodiment, and the components having functions similar to those of the first embodiment are omitted.

First, the conveyance timing correction in this second embodiment is described. Note that in the description below, the correction amount is calculated on the premise that the following conditions (1) to (6) are satisfied:

(1) the number of rotations of the photosensitive drum does not change even though the environment changes or the time has passed;

(2) the amount of change in distance from the primary transfer position to the secondary transfer position due to the expansion of the intermediate transfer belt is the same in the case of forming either the color image or the monochromatic image;

(3) the number of rotations of the photosensitive drum does not change in the case of forming either the color image or the monochromatic image;

(4) the linear velocity of the intermediate transfer belt does not change in the case of forming either the color image or the monochromatic image;

(5) the opening or closing of the cover does not change the position of the LEDA exposure; and

(6) the exchange of PCDU does not change the primary transfer position.

In the description below, "the detection of the displacement correction pattern formed in color" may be referred to as "the detection of the displacement correction pattern in the normal mode", "the reference value for the displacement correction pattern formed in color" may be referred to as "the reference value for the normal mode", "the detection timing correction pattern **200-1**" may be referred to as "the detection timing correction pattern (Y)R", and "the detection timing correction pattern **200-2**" may be referred to as "the detection timing correction pattern (Y)L".

Similarly, in the description below, "the detection of the displacement correction pattern formed in monochrome" may be referred to as "the detection of the displacement correction pattern in the monochromatic mode", "the reference value for the displacement correction pattern formed in monochrome" may be referred to as "the reference value for the monochromatic mode", "the detection timing correction pattern **210-1**" may be referred to as "the detection timing correction pattern (B)R", and "the detection timing correction pattern **210-2**" may be referred to as "the detection timing correction pattern (B)L".

In the case of the detection of the displacement correction pattern in the normal mode, the CPU **100** calculates the correction amount for the normal mode using Formula (1).

Here, the sampling length d**1** is, for example, 0.9961/α [μm], and the linear velocity adjustment factor α is, for example, 0.99.

In the case of the detection of the displacement correction pattern in the monochromatic mode, the CPU **100** calculates the correction amount for the normal mode using Formula (2).

When the previous detection of the displacement correction pattern is the detection of the displacement correction pattern in the normal mode, the CPU **100** controls the conveyance timing for the recording sheet to which the color image is transferred, using a value obtained by adding the offset according to the temperature change detected by the temperature and humidity sensor to the correction amount for the normal mode. When the previous detection of the displacement correction pattern is the detection of the displacement correction pattern in the monochromatic mode, the CPU **100** controls the conveyance timing for the recording sheet to which the monochromatic image is transferred, using a value obtained by adding the offset according to the temperature change detected by the temperature and humidity sensor to the correction amount for the monochromatic mode. Note that the temperature sensed by the temperature and humidity sensor may be the temperature inside the apparatus or outside the apparatus.

Specifically, when the previous detection of the displacement correction pattern is the detection of the displacement correction pattern in the normal mode, the CPU **100** calculates the offset ΔToffset using Formula (3), decides the position correction amount ΔP [μm] using Formula (4), and corrects and controls the timing of feeing paper from the paper feeding roller **13** and the timing for conveying the recording sheet by the paper conveyance belt **14** using the decided position correction amount ΔP.

$$\Delta T\text{offset}=(T\text{env}-\text{temperature at the detection of the displacement correction pattern in the normal mode})\times\beta\times\text{Belt [μm]} \tag{3}$$

Here, Tenv is the measurement result (temperature) of the temperature and humidity sensor during the printing, the transfer belt expansion coefficient β is, for example, 0.11×10^{-3} [/° C.] and the entire length of the transfer belt, Belt, is 750×10^{3} [μm], for example.

$$\Delta P=(\text{correction amount for normal mode}+\Delta T\text{offset}) \tag{4}$$

Similarly, if the previous detection of the displacement correction pattern is the detection of the displacement correction pattern in the monochromatic mode, the CPU **100** calculates the offset ΔToffset using Formula (5), decides the position correction amount ΔP using Formula (6), and corrects and controls the timing of feeding paper from the paper feeding roller **13** and the timing for conveying the recording sheet by the paper conveyance belt **14** using the decided position correction amount ΔP.

$$\Delta T\text{offset}=(T\text{env}-\text{temperature at the detection of the displacement correction pattern in the monochromatic mode})\times\beta\times\text{Belt [μm]} \tag{5}$$

$$\Delta P=(\text{correction amount for monochromatic mode}+\Delta T\text{offset}) \tag{6}$$

In this embodiment, the upper-limit and lower-limit values are set in the offset ΔToffset, and if ΔToffset≥1000 [μm], ΔToffset=1000 [μm] and if ΔToffset−1000 [μm], ΔToffset=−1000 [μm].

Note that the position correction amount ΔP is calculated before the start of the page. The temperature at the detection of the displacement correction pattern in the normal mode and the temperature at the detection of the displacement correction pattern in the monochromatic mode are stored in the ROM **102** after the measurement.

Next, the timing of executing the detection of the displacement correction pattern in the second embodiment is described. FIG. **12** is an explanatory view of the timing of executing the detection of the displacement correction pattern in the second embodiment. In this embodiment, basically, the detection of the displacement correction pattern is executed at the power input, at the restoration from the sleep mode, etc., before the start of the job, and after the end of the job;

however, the timing of execution is not limited thereto. For example, the execution may be triggered by temperature change over a certain range.

When the detection of the displacement correction pattern is executed, the image position correction and the conveyance timing correction are performed; in this case, it is not necessary to consider the offset ΔToffset in the conveyance timing correction. In other words, the CPU **100** may calculate the position correction amount ΔP from the correction amount for the normal mode or the correction amount for the monochromatic mode.

For example, it is assumed that the detection of displacement correction pattern in the normal mode is requested in the case of starting the job for the color. In this case, if the mode is the FC priority mode or the Bk priority mode, the CPU **100** executes the detection of the displacement correction pattern in the normal mode before the start of the job for the color.

In addition, it is assumed that the detection of displacement correction pattern in the normal mode is requested in the case of starting the job for the monochrome. In this case, if the mode is the FC priority mode, the CPU **100** executes the detection of the displacement correction pattern in the normal mode before the start of the job for the monochrome.

Further, it is assumed that the detection of displacement correction pattern in the monochromatic mode is requested in the case of starting the job for the monochrome. In this case, if the mode is the Bk priority mode or the color prohibition mode, the CPU **100** executes the detection of the displacement correction pattern in the monochromatic mode before the start of the job for the monochrome.

In FIG. **12**, "rest time" starts from the time at which the image forming motor for the image forming unit **16**B stops finally. "Detected rest time exceeded threshold" means that one of the following conditions is satisfied: the measurement result from a real-time clock included in the CTL **130** has exceeded 2880 minutes (48 hours); and a timer-up signal is active. "Light detected" is a function of detecting the brightness around the printer with an illuminance sensor, and if a dark state continues for a certain period, determining that there is no one who uses the printer and turning off the power. "SP" is the nonvolatile data stored in the ROM **102** whose control program can be changed depending on the condition or which can be changed in accordance with the state of the image by a service man.

For allowing the users to efficiently use the time other than the downtime, the image position correction is often executed at the end of the job in the general image forming apparatus. In contrast to this, in this embodiment, in order to minimize the situation that the conveyance deviation of the recording sheet is deteriorated without increasing the number of times of executing the image position correction, the image position correction by the detection that the rest time has exceeded the threshold and the image position correction at the end of the job are omitted. The image position correction may be executed at the initialization or the start-up time for fixing.

FIG. **13** is a flowchart of an example of a process of the conveyance timing correction in this embodiment.

First, the CPU **100** checks whether or not the previous detection of the displacement correction pattern (image position correction) has been performed in the normal mode (Step S**401**).

Subsequently, when the mode is the normal mode (Yes in Step S**401**), the CPU **100** acquires the correction amount for the normal mode from the ROM **102**, calculates the offset ΔToffset using Formula (3), and decides the position correction amount ΔP [μm] using Formula (4) (Step S**402**).

Meanwhile, when the mode is not the normal mode but the monochromatic mode (No in Step S**401**), the CPU **100** acquires the correction amount for the monochromatic mode from the ROM **102**, calculates the offset ΔToffset using Formula (5), and decides the position correction amount ΔP [μm] using Formula (6) (Step S**403**).

Subsequently, using the decided position correction amount ΔP, the CPU **100** corrects and controls the timing of feeding paper from the paper feeding roller **13** and the timing of conveying the recording paper by the paper conveyance belt **14** (Step S**404**).

According to this embodiment as above, in the case of not performing the image position correction, the CPU **100** predicts the expansion of the intermediate transfer belt as the offset of the temperature change and performs the conveyance control for the recording sheet. Thus, in this embodiment, the accuracy of the conveyance control for the recording sheet can be increased while the consumption of the developer is suppressed. In particular, in the case of using the LEDA head as the exposing mechanism as described in this embodiment, the displacement due to the temperature change is unlikely to occur, which is more preferable.

Third Embodiment

In the technique disclosed in Japanese Patent Application Laid-open No. 2008-76534, based on the timing of reading the first set of the displacement correction pattern, the timing of detecting the second and subsequent sets of the displacement correction patterns is decided. Thus, even though the intermediate transfer belt is expanded or contracted, the second set and subsequent sets of the displacement correction patterns can be read surely to perform the image position correction.

Moreover, the difference from the reference value of the detection time of the displacement correction pattern is calculated, and if the conveyance timing correction is performed based on the calculated difference, the conveyance control for the recording sheet considering the expansion or the contraction of the intermediate transfer belt becomes possible.

However, the conveyance timing correction described above is merely the correction of the displacement depending on the expansion of the intermediate transfer belt; in general, the conveyance timing for the recording sheet is adjusted at the shipment from the factory so that the image is formed at the correct position on the recording sheet or adjusted by the setting of the adjustment value in the user adjustment and the service adjustment, etc.

Here, in the case where the image forming unit to be used is different depending on the content of the image to be formed, the timing of conveying the recording sheet is preferably adjusted so that the image is formed at the correct position on the recording sheet for any content of the image to be formed.

However, in some cases, it is difficult to adjust the timing of conveying the recording sheet for every content of the image to be formed. In those cases, even though the conveyance timing correction is performed as above in the image formation with the content of the image to be formed in which the timing of conveying the recording sheet is not adjusted, the image cannot be formed at the correct position on the recording sheet.

In view of this, in the third embodiment, an example of forming the image at the correct position on the recording sheet is described. The description is mainly made of the difference from the first embodiment, and the components having the similar functions to those of the first embodiment are omitted.

The conveyance timing correction of the third embodiment is described. Note that in the description below, the correction amount is calculated on the premise that the following conditions (1) to (6) are satisfied:

(1) the number of rotations of the photosensitive drum does not change even though the environment changes or the time has passed;

(2) the amount of change in distance from the primary transfer position to the secondary transfer position due to the expansion of the intermediate transfer belt is the same in the case of forming either the color image or the monochromatic image;

(3) the number of rotations of the photosensitive drum does not change in the case of forming either the color image or the monochromatic image;

(4) the linear velocity of the intermediate transfer belt does not change in the case of forming either the color image or the monochromatic image;

(5) the opening or closing of the cover does not change the position of the LEDA exposure; and

(6) the exchange of PCDU does not change the primary transfer position.

In the description below, "the detection of the displacement correction pattern formed in color" may be referred to as "the detection of the displacement correction pattern in the normal mode", "the reference value for the displacement correction pattern formed in color" may be referred to as "the reference value for the normal mode", "the detection timing correction pattern **200-1**" may be referred to as "the detection timing correction pattern (Y)R", and "the detection timing correction pattern **200-2**" may be referred to as "the detection timing correction pattern (Y)L".

Similarly, in the description below, "the detection of the displacement correction pattern formed in monochrome" may be referred to as "the detection of the displacement correction pattern in the monochromatic mode", "the reference value for the displacement correction pattern formed in monochrome" may be referred to as "the reference value for the monochromatic mode", "the detection timing correction pattern **210-1**" may be referred to as "the detection timing correction pattern (B)R", and "the detection timing correction pattern **210-2**" may be referred to as "the detection timing correction pattern (B)L".

In the case of the detection of the displacement correction pattern in the normal mode, the CPU **100** calculates the correction amount for the normal mode using Formula (1).

In the case of the detection of the displacement correction pattern in the monochromatic mode, the CPU **100** calculates the correction amount for the monochromatic mode using Formula (2).

The CPU **100** then refers to the position adjustment information that represents for which one of the color image formation and the monochromatic image formation the position adjustment on the recording sheet has been performed. The position adjustment information may include the position adjustment amount. The position adjustment information is updated in the ROM **102** upon the position adjustment at the shipment from the factory, the assurance step, the user adjustment, or the service adjustment.

However, in the case where the reference value for the normal mode or the reference value for the monochromatic mode is measured again and updated by the user or the service man, the position adjustment is preferably performed as continuously as possible at the normal temperature and normal humidity and normal temperature in the apparatus.

If the position adjustment information represents the position adjustment performed on the recording sheet relative to the color image formation, the CPU **100** controls the timing of conveying the recording sheet to which the color image is transferred, using the correction amount for the normal mode, and controls the timing of conveying the recording sheet to which the monochromatic image is transferred, using the value obtained by correcting the correction amount for the monochromatic mode with the value based on the difference between the second reference value and the first reference value.

When the position adjustment information represents the position adjustment performed on the recording sheet relative to the monochromatic image formation, the CPU **100** controls the timing of conveying the recording sheet to which the color image is transferred, using the value obtained by correcting the correction amount for the normal mode with the value based on the difference between the first reference value and the second reference value, and controls the timing of conveying the recording sheet to which the monochromatic image is transferred, using the correction amount for the monochromatic mode.

Note that in this embodiment, it is assumed that the position adjustment information represents the position adjustment performed on the recording sheet relative to the color image formation. This is because, in some apparatus designs, in the case of printing a color image, the monochromatic image will not be printed in a state that the photosensitive drums **17**C, **17**M, and **17**Y are separated from the intermediate transfer belt **22** but in the case of printing a monochromatic image, the color image with only the monochromatic component may be printed in a state that the photosensitive drums **17**C, **17**M, and **17**Y are in contact with the intermediate transfer belt **22**. Therefore, the detailed description is made of the case where the position adjustment information represents the position adjustment performed on the recording sheet relative to the color image formation.

In this case, in the case of performing the color image formation, the CPU **100** decides the position correction amount ΔP [μm] from the correction amount for the normal mode, and using the position correction amount ΔP, the CPU **100** corrects and controls the timing of feeding paper from the paper feeding roller **13** and the timing of conveying the recording sheet by the paper conveyance belt **14**. On the other hand, in the case of performing the monochromatic image formation, the CPU **100** decides the position correction amount ΔP [μm] from the correction amount for the monochromatic mode, and using Formula (7), the CPU **100** updates the position correction amount ΔP and using the updated position correction amount ΔPupdated, the CPU **100** corrects and controls the timing of feeding paper from the paper feeding roller **13** and the timing of conveying the recording sheet by the paper conveyance belt **14**.

$$\Delta P\text{updated}=\Delta P+\{\text{reference value for the monochromatic mode}-\text{reference value for the normal mode}\}\times\text{sampling length } d1\ [\mu\text{m}] \tag{7}$$

Here, the sampling length d1 is, for example, 0.9961/α [μm], and α (linear velocity adjustment factor) is, for example, 0.99.

Note that the position correction amount ΔP is calculated before the start of the page. In this embodiment, the position correction amount ΔP is updated when the monochromatic image formation is performed. However, in order to effectively updating the position correction amount ΔP, i.e., to form the monochromatic image at the correct position on the recording sheet, it is necessary, as the premise condition, to detect the displacement amount of the color image relative to the recording sheet in the assurance step, user adjustment, or service adjustment and to update the adjustment value so that the image is formed at the correct position on the recording sheet.

FIG. **14** is a flowchart of an example of a process of correcting the conveyance timing in this embodiment. The process shown in FIG. **14** is performed before the start of the page.

First, in the case of performing color printing (Yes in Step S**501**), since the position adjustment information represents that the position adjustment on the recording sheet has been performed relative to the color image formation, the CPU **100** acquires the correction amount for the normal mode from the ROM **102** and decides the position correction amount ΔP (Step S**502**).

Meanwhile, in the case of performing monochromatic printing (No in Step S**501**), since the position adjustment information represents that the position adjustment on the recording sheet has been performed relative to the color image formation, the CPU **100** acquires the correction amount for the monochromatic mode from the ROM **102** and decides the position correction amount ΔP and further updates the position correction amount ΔP using Formula (7) (Step S**503**).

Subsequently, the CPU **100** corrects and controls the timing of feeding paper from the paper feeding roller **13** and the timing of conveying the recording sheet by the paper conveyance belt **14** using the decided or updated position correction amount ΔP (Step S**504**).

As described above, in this embodiment, even though the displacement amount of the image relative to the recording sheet is adjusted for the color only, the timing difference between the color and the monochrome can be absorbed using the difference between the second reference value and the first reference value; thus, the monochromatic image can be formed at the correct position on the recording sheet.

Further, even though the displacement amount of the image relative to the recording sheet is adjusted for the monochrome only, the color image can be formed at the correct position on the recording sheet similarly.

According to this embodiment, in any case of the color and monochrome, the image forming unit in the most upstream side in the image forming process forms the detection timing correction pattern; therefore, the influence of the measurement error from the hardware can be reduced and the accuracy of the image position correction and the conveyance timing correction can be increased further.

MODIFIED EXAMPLE

The present invention is not limited to the above embodiments, and various modifications are possible. In the above embodiment, the exposure mechanism is formed using the LEDA head as a solid-state scanning type writing device; however, the exposure mechanism may be formed using another solid-state scanning type writing device such as an organic EL (electroluminescence) head, an LD (laser diode) array head, or a surface emission laser. Those devices are also preferable as aforementioned, and since a unit type optical system as the LD writing device is not used in the solid-state scanning type writing device, the displacement of image transfer position easily occurs randomly for each image forming unit; thus, those are particularly preferable in the present invention.

However, the exposure mechanism is not limited to the solid-state scanning type writing device but may be a scanning type writing device including a unit type optical system. This is because, even if the scanning type writing device is used in the exposure mechanism, the displacement of the image transfer position is not necessarily prevented in the image forming unit.

Although the above embodiments have described the example in which the intermediate transfer belt is extended, the present invention is similarly applicable to the case where the intermediate transfer belt is contracted.

According to the present invention, an effect of increasing the accuracy of the conveyance control of the recording sheet while reducing the extra consumption of a developer can be obtained.

Although the invention has been described with respect to specific embodiments for a complete and clear disclosure, the appended claims are not to be thus limited but are to be construed as embodying all modifications and alternative constructions that may occur to one skilled in the art that fairly fall within the basic teaching herein set forth.

What is claimed is:

1. An image forming apparatus comprising:

a plurality of image forming units configured to form an image in different colors;

a conveyance mechanism configured to convey a first pattern formed using at least a first image forming unit of the plurality of image forming units, that forms the image in a first color, and to convey a second pattern formed using a second image forming unit of the plurality of image forming units, that forms the image in a second color;

a detection unit configured to detect the first pattern conveyed by the conveyance mechanism and the second pattern conveyed by the conveyance mechanism; and

a control unit configured to control, when a first condition is satisfied, a timing of conveying a recording sheet to which the image formed using at least the first image forming unit is transferred on the basis of a first time required after the formation of the first pattern and before the detection of the first pattern by the detection unit, the control unit being further configured to control, when a second condition is satisfied, a timing of conveying the recording sheet to which the image formed using the second image forming unit is transferred on the basis of a second time required after the formation of the second pattern and before the detection of the second pattern by the detection unit,

the first condition being satisfied upon

a mode of the image forming apparatus being in a priority mode prioritizing color image formation, or

a mode of the image forming apparatus being in either a priority mode prioritizing monochromatic image formation or in a color prohibition mode prohibiting color image formation, wherein a previously imaged pattern is the first pattern, and

the second condition being satisfied upon

a mode of image forming apparatus being in either the priority mode prioritizing monochromatic image formation or in the color prohibition mode prohibiting color image formation, wherein a previously imaged pattern is the second pattern.

2. The image forming apparatus according to claim **1**, further comprising a storage unit configured to store a first reference value as a reference value of the first time and a second reference value as a reference value of the second time, wherein the control unit controls, when the first condition is satisfied, the timing of conveying the recording sheet on the basis of a difference between the first time and the first reference value, and

the control unit controls, when the second condition is satisfied, the timing of conveying the recording sheet on the basis of a difference between the second time and the second reference value.

3. The image forming apparatus according to claim **1**, wherein

the first color is a color other than black used in color image formation,

the second color is black,

the first image forming unit is an image forming unit located in the most upstream side of a conveying direction of the conveyance mechanism among the image forming units for performing color image formation in the image forming units, and

the second image forming unit is an image forming unit located in the most upstream side of the conveying direction of the conveyance mechanism among the image forming units for performing monochromatic image formation in the image forming units.

4. The image forming apparatus according to claim **3**, wherein

the first pattern is formed using the image forming unit performing color image formation, of the plurality of image forming units,

the second pattern is formed using the image forming unit performing monochromatic image formation, of the plurality of image forming units, and

the control unit is configured to control an exposure timing for the image forming unit performing color image formation using a detection result of the first pattern from the detection unit, and is configured to control an exposure timing for the image forming unit performing monochrome image formation using a detection result of the second pattern from the detection unit.

5. The image forming apparatus according to claim **1**, further comprising a buffer mechanism configured to absorb expansion and contraction of the conveyance mechanism, wherein

the buffer mechanism is provided between the image forming unit located in the most downstream side of a conveying direction of the conveyance mechanism and the detection unit.

6. An image forming apparatus comprising:

a plurality of image forming units configured to form an image in different colors;

a conveyance mechanism configured to convey a first pattern formed using at least a first image forming unit among the image forming units, that forms the image in a first color, and convey a second pattern formed using a second image forming unit among the image forming units, that forms the image in a second color;

a detection unit configured to detect the first pattern conveyed by the conveyance mechanism and the second pattern conveyed by the conveyance mechanism;

a storage unit configured to store a first temperature at the detection of the first pattern and a second temperature at the detection of the second pattern; and

a control unit configured to control, when the first pattern has been previously detected, a timing of conveying a recording sheet to which the image formed using at least the first image forming unit is transferred on the basis of a first time required after the formation of the first pattern and before the detection of the first pattern by the detection unit, the first temperature, and a current temperature, and the control unit configured to control, when the second pattern has been previously detected, a timing of conveying the recording sheet to which the image formed using the second image forming unit is transferred on the basis of a second time required after the formation of the second pattern and before the detection of the second pattern by the detection unit, the second temperature, and the current temperature.

7. The image forming apparatus according to claim **6**, wherein

the storage unit further stores a first reference value as a reference value of the first time and a second reference value as a reference value of the second time, and

the control unit controls, when the first pattern has been previously detected, the timing of conveying the recording sheet to which the image formed by using at least the first image forming unit is transferred on the basis of a value obtained by adding a value based on a difference between the first temperature and the current temperature to a value based on a difference between the first time and the first reference value, and the control unit controls, when the second pattern has been previously detected, the timing of conveying the recording sheet to which the image formed by using the second image forming unit is transferred on the basis of a value obtained by adding a value based on a difference between the second temperature and the current temperature to a value based on a difference between the second time and the second reference value.

8. The image forming apparatus according to claim **6**, wherein

the first temperature, the second temperature, and the current temperature are temperatures inside or outside the apparatus.

9. The image forming apparatus according to claim **6**, wherein

the first color is a color other than black used in color image formation,

the second color is black,

the first image forming unit is an image forming unit located in the most upstream side of a conveying direction of the conveyance mechanism among the image forming units for performing color image formation in the image forming units, and

the second image forming unit is an image forming unit located in the most upstream side of a conveying direction of the conveyance mechanism among the image forming units for performing monochromatic image formation in the image forming units.

10. The image forming apparatus according to claim **9**, wherein

the first pattern is formed using the image forming unit performing color image formation, of the plurality of image forming units,

the second pattern is formed using the image forming unit performing monochromatic image formation, of the plurality of image forming units, and

the control unit is configured to control an exposure timing for the color using a detection result of the first pattern from the detection unit, and is configured to control an exposure timing for the monochrome using a detection result of the second pattern from the detection unit.

11. The image forming apparatus according to claim **10**, wherein

the control unit is configured to correct an image position by controlling the exposure timing when temperature has changed over a certain range or a power-off time has continued for a certain period.

12. The image forming apparatus according to claim **11**, further comprising a controller, wherein

the power-off time is configured to be measured using a real-time clock included in the controller or an active timer-up signal output from the controller.

13. The image forming apparatus according to claim **12**, wherein

the power-off time is configured to be measured from a time when a driving motor for the image forming unit performing the monochromatic image formation stops finally.

14. The image forming apparatus according to claim **10**, wherein

the control unit is configured to correct an image position by controlling the exposure timing at initialization or start-up for fixing.

15. An image forming apparatus comprising:

a plurality of image forming units configured to form an image in different colors;

a conveyance mechanism configured to convey a first pattern formed using at least a first image forming unit among the image forming units, that forms the image in a first color, and convey a second pattern formed using a second image forming unit among the image forming units, that forms the image in a second color;

a detection unit configured to detect the first pattern conveyed by the conveyance mechanism and detecting the second pattern conveyed by the conveyance mechanism;

a storage unit configured to store therein position adjustment information representing for which one of the first image and the second image position adjustment on a recording sheet has been performed, a first reference value as a reference value of a first time required after the image formation of the first pattern and before the detection of the first pattern by the detection unit, and a second reference value as a reference value of a second time required after the image formation of the second pattern and before the detection of the second pattern by the detection unit; and

a control unit configured to control, when the position adjustment information represents that the position adjustment for the first image on the recording sheet has been performed, a timing of conveying the recording sheet to which the image formed by the first image forming unit is transferred on the basis of the first time and the first reference value and controlling a timing of conveying the recording sheet to which the image formed by the second image forming unit is transferred on the basis of the second time, the first reference value, and the second reference value, and the control unit configured to control, when the position adjustment information represents that the position adjustment for the second image on the recording sheet has been performed, a timing of conveying the recording sheet to which the image formed by the first image forming unit is transferred on the basis of the first time, the first reference value, and the second reference value and controlling a timing of conveying the recording sheet to which the image formed by the second image forming unit is transferred on the basis of the second time and the second reference value.

16. The image forming apparatus according to claim **15**, wherein

the control unit controls, when the position adjustment information represents that the position adjustment for the first image on the recording sheet has been performed, the timing of conveying the recording sheet to which the image formed by the first image forming unit is transferred on the basis of a difference between the first time and the first reference value and the timing of conveying the recording sheet to which the image formed by the second image forming unit is transferred on the basis of a value obtained by adding a value based on a difference between the second reference value and the first reference value to a value obtained based on a difference between the second time and the second reference value, and

the control unit controls, when the position adjustment information represents that the position adjustment for the second image on the recording sheet has been performed, the timing of conveying the recording sheet to which the image formed by the first image forming unit is transferred on the basis of a value obtained by adding a value based on a difference between the first reference value and the second reference value to a value based on a difference between the first time and the first reference value and the timing of conveying the recording sheet to which the image formed by the second image forming unit is transferred on the basis of a difference between the second time and the second reference value.

17. The image forming apparatus according to claim **15**, wherein

the first color is a color other than black used in color image formation,

the second color is black,

the first image is a color image,

the second image is a monochromatic image,

the first image forming unit is an image forming unit located in the most upstream side of a conveying direction of the conveyance mechanism among the image forming units performing color image formation in the image forming units, and

the second image forming unit is an image forming unit located in the most upstream side of a conveying direction of the conveyance mechanism among the image forming units performing monochromatic image formation in the image forming units.

18. The image forming apparatus according to claim **17**, wherein

the first pattern is formed using the image forming units performing color image formation among the image forming units,

the second pattern is formed using the image forming unit performing monochromatic image formation among the image forming units, and

the control unit controls an exposure timing for the color using a detection result of the first pattern from the detection unit, and controls an exposure timing for the monochrome using a detection result of the second pattern from the detection unit.

19. The image forming apparatus according to claim **15**, wherein

the position adjustment information represents that the position adjustment for the first image on the recording sheet has been performed.

20. The image forming apparatus according to claim **15**, wherein

the position adjustment is performed when the first reference value or the second reference value is updated.

* * * * *